A political ecology of bovine tuberculosis eradication in Northern Ireland

ROBINSON, PHILIP,ALEXANDER

Department of Geography

Durham University

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Philip Alexander Robinson BVMS DSVM MSc MRCVS

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Abstract

Bovine tuberculosis (TB) is arguably the most important animal health problem in the world. TB is endemic in the Global South, and also affects several nations and regions with highly developed cattle farming industries and statutory eradication programmes in the European Union, including Northern Ireland. The disease has implications for livestock agriculture, wildlife ecology, public health, and the national economy. In addition to scientific and technical complexities, socio-economic and socio-cultural factors affect efforts to control the disease. Disease problems such as TB at the human-nature interface are complex and indeterminate, and require innovative multidisciplinary research to find holistic and workable solutions: geography has much to contribute.

This investigation uses a political ecology framework, and provides explanations for the historical and geographical patterns of the disease through a 'chain of explanation' approach (Blaikie & Brookfield, 1987). It utilizes political ecology, STS, rural, cultural, health, 'more-than-human' and veterinary literatures to produce a political ecology of animal disease control in the First World. Significantly, this account is as much about people and politics as it is about land use, technology, cattle, badgers, bacteria and disease. Conducted from the positionality of being a vet and a farmer's son, and based on ethnographic interviews with farmers, vets, policy makers and other agricultural industry representatives, the links in the chain explain why the statutory eradication programme has not yet been successful in achieving its original aim. The disease continues to spread across the landscape and evades efforts to eradicate. The thesis shows how TB permeates time and space shaped by global economic forces, political structures, cultural practices and complex ecologies. TB, often invisible and underestimated, must be made visible again. New network structures are required to rescale governance and move closer to the target of TB eradication.

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List of Abbreviations

AD	Aujeszkys disease
AHWI	Animal Health and Welfare Inspectors
BSE	Bovine spongiform encephalopathy
BVDV	Bovine viral diarrhoea virus
CAFRE	College of Agriculture, Food and Rural Enterprise
CAP	Common Agricultural Policy
DARD	Department of Agriculture and Rural Development
FMD	Foot and Mouth Disease
FVO	Food and Veterinary Office
GIS	Geographic Information System
LCT	Lateral check test
NI	Northern Ireland
NVL	No visible lesions
NZ	New Zealand
PVP	Private veterinary practitioner
RBCT	Randomised Badger Culling Trial
REF	Research Excellence Framework
ROI	Republic of Ireland
SFP	Single Farm Payment
TB	Bovine tuberculosis
TVR	Test, vaccinate or remove (badger management strategy)
UK	United Kingdom
VO	Veterinary Officer
VOT	Veterinary Officer (Testing)
WHO	World Health Organisation

Declaration

I, Philip Alexander Robinson, declare that this thesis represents my own work and has not been previously submitted for the award of any other academic degree or diploma. I certify that the use of material from other sources has been properly and fully acknowledged.

Statement of Copyright

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Dedication

To Lynn, Keziah, Jude, Joanna and Melody

and

To the memory of my grandfather James Robinson

He instilled in me a love of learning

Soli Deo Gloria

Chapter 1: Introducing a political ecology of TB in Northern Ireland

Bovine tuberculosis (TB), an infectious disease of cattle caused by the bacterium *Mycobacterium bovis*, is an animal health problem with global significance. The disease is endemic in the Global South, and continues to be problematic even in such developed nations as the United Kingdom (UK), Republic of Ireland (ROI), Spain and New Zealand. It has a long history, and since Robert Koch cultured the tubercle bacillus in 1882 (Collins & Grange, 1983), TB has been the focus of intense research interest, and much controversy.

TB has the potential to infect humans, and is therefore known as a *zoonosis*. This risk is low in the developed world due to the pasteurization of milk and intensive eradication programmes removing infected cattle before they reach more advanced and more infectious stages of the disease. In addition to cattle, there are also reservoirs of infection in various wildlife species around the world which further complicate efforts to control the disease in farmed livestock. Badgers are the main wildlife reservoir in the UK and ROI.

TB has significant economic implications for agriculture. European Union (EU) legislation requires the eradication of TB from the territories of Member States (Council Directive 77/391/EEC), primarily to facilitate the free trade of animals and animal products (Council Directive 64/432/EEC), but also to protect human health. Within the regions of the UK, Northern Ireland (NI) has had one of the highest rates of TB for many years. TB remains an expensive and frustrating problem for state veterinary authorities seeking to eradicate the disease, with £317M being spent on the eradication programme in NI between 1996 and 2011 (NI Assembly, 2012a). TB in NI is therefore a significant economic problem for First World capitalist livestock agriculture, but with the controversial involvement of a wildlife reservoir of infection in the European badger (*Meles meles*), it also has ecological and environmental dimensions.

Disease eradication remains elusive in NI despite having one of the most sophisticated TB control systems in the world. It involves a large cadre of private and state vets carrying out intensive testing of cattle, alongside strict animal movement controls and dedicated enforcement of legislation. The vets are like Sisyphus in Homer's *Odyssey*, forever pushing the boulder to the brim of the hill only for it to roll to the bottom again as the sweat lashes from his brow (Homer, 1946:155). TB keeps on coming back, and could be described as a conundrum.

Disease problems at the human-nature interface, such as TB, are often complex and indeterminate. They require multidisciplinary research efforts to find workable solutions: geography has much to contribute. This research therefore uses the case study of TB to argue that analysing veterinary geographies of disease is important in understanding and controlling animal disease. The TB story may not be as simple as on the surface it may appear: it is much more than 'an infectious, granulomatous disease caused by acid-fast bacilli of the genus *Mycobacterium*' (Anon, 2005:549). Using ethnographic studies with farmers, vets, policy makers and other relevant stakeholders, this research seeks to find out why the TB eradication programme in NI has not yet been completely successful, and whether a social science approach can help provide answers to the conundrum of intensive effort with incomplete success.

The framework chosen for the research is political ecology as it can justifiably be described as interdisciplinary and boundary-crossing, and perfect for considering TB. Rooted primarily in geography, but with strong influences from anthropology, the sub-field of political ecology uses concepts and methodologies from across the social and natural sciences.

What is political ecology?

Political ecology has 'come of age' (Muldavin, 2008: 687). Developed from the 'uneasy marriage of cultural ecology and agrarian political economy' (Goldman & Turner, 2011: 6) in the 1970s and 1980s, political ecology has gone from strength to strength to become a core sub-field of geography (especially in North America) with its own key texts (e.g. Bryant & Bailey, 1997; Neumann, 2005; Peet *et al.*, 2011; Robbins, 2012a; King & Crews, 2013), case study monographs (e.g. Guthman, 2004; Prudham, 2005; Davis, 2007; Robbins, 2007) and many journal articles.

The diversity of topics covered in political ecology is vast, and as a result, defining political ecology has become difficult. Piers Blaikie's pioneering approach was to introduce political economy and its relevance to environmental problems such as soil erosion through a 'bottom-up' approach starting with the farmers who made the decisions on how the land under their control was utilized (Blaikie, 1985). Appreciating the rhythms of everyday life on the ground, such research seeks to explore the wider contexts within which these activities are shaped and constructed. Blaikie and Brookfield's (1987: 17) oft-cited definition of political ecology as a combination of 'ecology and a broadly defined political economy' remains valid, and this important focus on the influence of political economic forces on the environment is often overlooked outside of political ecology (Robbins, 2012a).

Robbins (2012a: 4-5) also emphasizes the practical nature of political ecology, suggesting that it is not just a body of knowledge, but 'something people do' or 'a community of practice'. As it has developed, 'political ecological analysis and argument have shifted from a focus on the destruction of environments, with a stress on human influences, to a more powerful focus on the production of socio-environments and their co-constitution by many kinds of human and non-human actors' (Robbins, 2012a:5). For example, political ecologists investigate the interactions between humans, animals and land in wildlife-society conflicts which involve the conjoining of the human, non-human, social and material (Abel & Blaikie, 1986; Neumann, 1992; Gupta, 2013). The key argument is that investigating such complex hybrid issues cannot remain solely the preserve of *natural* scientists. As Blaikie (1995: 2) asserts, 'environmental issues are also social issues', and there is therefore a role for the *social* scientist in unravelling and explaining complexity.

Historically, the bulk of research in political ecology has been in developing world contexts linked to peasants and agrarian change, however this pattern is changing, and scholars have developed specifically *urban* political ecology approaches (e.g. Swyngedouw & Heynen, 2003; Lawhon *et al.*, 2014). There have been repeated calls for the expansion of political ecology to engage First World problems (McCarthy, 2002; Robbins, 2004; Schroeder, 2005). These calls have certainly been heeded, and there have been an ever increasing number of applications of political ecology to issues in the Global North involving a wide range of individuals and institutions, and covering topics such as industrial fisheries (Greenberg, 2006; Mansfield, 2007; Christiansen, 2013), water privatization (Bakker, 2004), milk production (Du Puis & Block, 2008), pesticide use (Biehler, 2009; Galt, 2010), livestock farming (Emel & Neo, 2011) and manipulation of the honeybee (Kosek, 2010).

Political ecology has also been applied to health issues in both the developed and developing world, although this literature has been slower to develop. Mayer argued that political ecology was ideal for studying disease holistically within medical geography (Mayer, 1996; Mayer, 2000), and King (2010) advocated studying the political economy of disease in concert with the health discourses of both actors and institutions, and the systems within which they operate. Others have demonstrated its usefulness in analysing the complexities of zoonotic diseases of animals, but focusing mainly on brucellosis in wildlife and farmed cattle (Morris & McBeth, 2003; Bienen & Tabor, 2006; Robbins, 2006; Bidwell, 2010).

In summary, political ecology brings environment and society together (Blaikie, 1995), and explores nature in its widest sense. As Bridge (2011: 221) states: 'Political ecology shares the revelatory ambition of the "production of nature" thesis: of showing how apparently 'natural' phenomena – soil erosion, famine, scarcity, population pressure [and *disease*, I would add] – are, at least in part, social in origin.' It acknowledges the social, economic and political aspects of environmental and ecological controversy, and encourages all dimensions of the controversy to be analysed together.

TB and political ecology

The relevance and application of political ecology will be explored more in each of the chapters of this thesis, but given this overview of the literature, there is scope for further development using intensive livestock production as the context. Galt (2013a) specifically calls for more political ecology research on First World agri-food systems to address what he sees as a surprising gap in the literature.

Responding to Galt's (2013a) call, this investigation of TB in NI fits well within political ecology and is the first study of TB using such a framework. TB is an intractable First World problem with important consequences for agricultural economy. Humans and animals meet with bacteria resulting in the on-going diffusion of disease, despite concentrated efforts to govern and limit the transmission. As Robbins suggests, 'placed at the beginning of a political ecology tale, contradictions compel fascinating mysteries worthy of socio-ecological investigation' (Robbins, 2012a: 95). Undoubtedly there are 'apparent mismatches between practice and expectation and between "common sense" and complex reality' (Robbins, 2012a: 95) for a disease which seems to foil the best of human schemes: a Gordian knot indeed. But a political ecology approach can provide a vehicle to 'unravel cognitive knots and explain the unexplainable' (Robbins, 2012a: 95).

Whilst human health 'exists at the interface of environment and society' and 'at the nexus of ecologies and politics' (Crews & King, 2013: 1), I will argue that the same holds for *animal* health. Nature is not external to society; rather, both are intertwined and co-produced, and these 'socio-natures … are products and processes which are neither wholly social nor wholly biophysical' (Bridge, 2011: 228). A failure to eradicate TB in NI is more than merely the failure to force a microbe into submission due to its unpredictable behaviours, but is also due to complex socio-economic and political contingencies connecting farmers, vets, the state and the wider political economy of intensive agricultural livestock production systems. These factors are poorly understood for TB, and a recent review of the natural science evidence base acknowledged the importance and need for further social science research to plot a way forward (Godfray *et al.*, 2013: 4).

This is where the benefits of a political ecology approach come in, allowing all angles to be simultaneously investigated in an overarching framework encompassing the dialectical relationships between the human and the non-human and between society and the environment, each influencing the other. By having a balanced consideration of the biophysical and ecological alongside the political and socio-economic, Vayda and Walters' (1999) criticism of the political ecological method - 'politics without ecology' - can be avoided. An intermediate way must be found between the extremes of social constructionism, where the agency of the biophysical, non-human world is overlooked (Boyd *et al.*, 2001), and environmental determinism, where the biophysical environment fundamentally shapes human nature and society (Castree, 2005).

Merging political ecology and Science and Technology Studies

Heeding earlier encouragements to do so (Watts & McCarthy, 1997; Castree & Braun, 1998; Goldman & Schurman, 2000), there is a growing trend for political ecology and Science and Technology Studies (STS) to collaborate and interchange concepts from both sub-fields (Goldman & Turner, 2011; Lave, 2012; Robbins, 2012a: 76-80). This political ecology of TB also borrows concepts from, and is shaped by, STS literatures.

Emerging from a group of sociologists, anthropologists and philosophers in the 1960s/1970s interested in how 'scientific knowledge is generated and legitimated' (Castree, 2005: 189), STS made the assumption that science and technology were 'thoroughly social activities' amongst communities of practitioners who shared common standards and modes of inquiry to construct scientific knowledge (Sismondo, 2004: 10). Early STS practitioners therefore typically followed scientists through their work in the 'laboratory', and studied how 'science gains power from ... its ability to manipulate nature and measure nature's reactions, and its ability to translate those measurements across time and space to other laboratories and other contexts' (Sismondo, 2004: 64).

According to Sismondo (2004), key themes in the STS literature have been laboratory work (Latour & Woolgar, 1979); scientific controversies (Jasanoff, 1987); social construction of reality (Latour, 1987); expertise and lay knowledge (Wynne, 1996); standardization and objectivity (Porter, 1995); creating order and mapping science (Callon *et al.*, 1986); and the relational materialism of Actor-Network Theory (Callon, 1986). John Law (2008a) traces how STS has moved on to embrace notions of performativity, multiplicity and ontological politics, especially through the work of feminist STS scholars such as Annmarie Mol. Throughout all of this sizeable body of work is an emphasis on exploring science as culture and practice through case study (Law, 2008a).

As Goldman and Turner (2011:5) contend, bringing STS concepts and tools into conversation with political ecology allows political ecologists to 'better understand the politics of environmental knowledge'. In particular, insights from STS benefit political ecology by premising that: knowledge is situated; expertise can be challenged in different contexts; knowledge circulates through networks; science and society are co-produced; and knowledge is political (Goldman & Turner, 2011: 14). Combining the toolboxes has the potential to help 'understand how knowledge becomes information, how information is shared and transformed, why certain knowledge constructs travel within and across different social worlds and policy arenas, and how collaboration can happen without consensus' (Goldman & Turner, 2011: 21). There is particular merit in examining the 'multiplicity of knowledge productions' (Turner, 2011: 26) that come from the different actors in an environmental problem.

Robbins (2012b: 884) affirms that merging political ecology and STS nullifies the views of scholars who think that ecology and the material are bypassed in political ecology, and that politics is overlooked in STS. Political ecology benefits from the STS emphasis on the role of knowledge production and knowledge circulation; reciprocally, STS benefits from a political ecology influence to better appreciate political economy and the importance of unequal power relations. Combining both fields merges 'the goals of theoretical interest and activism' (Sismondo, 2010:21) from both STS and political ecology to engage in the politics and democratization of science in the public sphere. This interface of 'science, technology, law, and government' (Sismondo, 2010:21), or, as Braun and Whatmore (2010) put it 'technoscience, democracy and public life,' is where TB sits, and where it must be engaged as 'political matter' (Braun & Whatmore, 2010).

In turning to STS, I do not seek to argue a case for explicitly merging Actor-Network-Theory (ANT) with political ecology, although some scholars do (e.g. Rudy & Gareau, 2005; Gareau, 2005; Perkins, 2007). An ANT approach risks ignoring or underplaying political-economic relations (Fine, 2005; Lave, 2011) which are important in TB control: I explore 'the extent to which agriculture … becomes a capitalistically run branch of industry' or 'capitalist production sets up stall in the countryside' (Marx, 1976: 952-953). Robbins (2013), whilst accepting the attractiveness of ANT (and himself heavily influenced by ANT and assemblage theory), states that the political implications of the network have to be recognised, and 'ANT eschews structural explanations that might point toward the role of elite power, institutionalised habits, and the asymmetry of the different players within an assemblage' (Robbins, 2013: 315). Taylor (2011: 87) is similarly critical of ANT and specifically its usefulness to political ecology, stating that it 'dull(*s*) the analysis of human purposes, motivations, imagination, and action'. Murdoch (1997) thinks that ANT pursues thorough description rather than seeking to find causes.

Having stated a case against merging ANT with political ecology, I still see merit in using the concepts of 'networks' and 'relations', with a focus on a 'more-than-human' (Whatmore, 2002) geographical approach to 'networked disease' (Ali & Keil, 2008). STS scholars have had a lot to say about animal disease networks, focusing particularly on Foot-and-Mouth Disease (FMD) and how it links viruses, animals, people and institutions (Law, 2006; Law, 2008b; Law & Mol, 2008a; Law & Mol, 2008b; Law, 2010a; Law & Mol, 2011; Law & Moser, 2012). The 'networking of pathogens, environments, and knowledge systems' (Scott *et al.*, 2012: 979) allows us to better investigate and understand disease. Bringing society and the environment, the human and the non-human together, and examining their multiple and complex networked relations clearly falls within the remit of political ecology (Robbins, 2012a). Robbins (2013: 315) makes the case that 'the emphasis is … on the diversity of players and their mutual influence on one another'; in other words, their 'entanglement.' In this vein, at various points in the thesis I also use the concept of the 'assemblage', employed in STS and geography literatures as a gathering of 'heterogeneous elements that may be human and non-human, organic and inorganic, technical and natural' (Anderson & McFarlane, 2011: 124) with 'liaisons … between them' (Deleuze & Parnet, 2006: 52).

Chains of explanation, webs of relation

My investigative approach, then, is to create a political ecology following in the tradition of pioneer practitioner Piers Blaikie's work in the 1980s, carried on and developed by Paul Robbins and others within the last decade. This produces a political ecology which is influenced by STS, and which bridges both the social and natural sciences. It takes the approach of what has been argued (Muldavin,

2008) are the sub-discipline's foundational texts: *The political economy of soil erosion in developing countries* (Blaikie, 1985), and *Land degradation and society* (Blaikie & Brookfield, 1987), specifically the 'chain of explanation' approach introduced in the second book which starts the analysis with the land managers and their relations with the land, and incrementally scales up to consideration of the global (p. 27). According to Rocheleau (2008), this pioneering work established five hallmarks of policy-relevant political ecology research: (i) multiple methods, objectives, actors and audiences; (ii) integration of social and biophysical analysis of power relations and environment; (iii) multi-scale analysis; (iv) empirical observation and data gathering at household and local level; (v) chains of explanation combining structure and agency. Rocheleau suggests that the Blaikie-esque approach of applied field-based research consists of 'soiled hands, muddy boots and multiple affiliations' (Rocheleau, 2008: 719), and it seems particularly apt given my personal history and positionality as a farmer's son and vet, now researching TB from the standpoint of academia as a human geographer.

Blaikie further developed the chain of explanation approach in subsequent works (Blaikie, 1989; 1995). Robbins and Bishop (2008: 747) argue that 'the chain of explanation ... has not outlived its usefulness,' and 'Blaikie's political ecology is as current as ever' (Robbins & Bishop, 2008: 754). Others have taken it up since then to study, for example, cotton production in Mali (Benjaminsen *et al.*, 2010) and the destruction of trees by the mountain pine beetle in Canada (Petersen & Stuart, 2014). The strength of the chain of explanation approach is in providing a means to disentangle the complexity of the whole; each link in the chain provides further clarification and explanatory traction in this political ecology of TB. Nevertheless, the chain of explanation has also been the subject of critique.

An early criticism came from Black (1990) who thought that in Blaikie and Brookfield's' (1987) model of decision-making in land management, political economy was classified as 'exogenous' to the model, with a unidirectional effect on land degradation, rather than working in both directions. Peet and Watts (1993: 239) suggest that the 'chains of explanation seem incapable of explaining how factors become causes,' and later repeated this criticism (Peet & Watts, 1996:8). Blaikie himself thought that 'the easiest task is to identify the links, but it is more difficult to operationalize them' (Blaikie, 1995: 19). Jones (2008) thought that the chain of explanation approach had become rare in political ecology literatures, with some having viewed it as overly structuralist, and needing to place more emphasis on power struggles and resistance. Muldavin describes how Blaikie developed an approach to political ecology in his later work which retained influences from its Marxist and structural roots, but combined them with post-structural insights giving 'a much more explicit treatment of knowledge and power' (Muldavin, 2008: 691) whilst maintaining a degree of scepticism about the 'post-structural turn' itself. Despite their support for the approach, Robbins and Bishop (2008) qualify this by suggesting that STS insights have greatly added to the value of such work and enrich its theoretical underpinning.

Doolittle (2010: 78) cautions that chains of explanation can lead to 'simplistic linear and hierarchical thinking', and instead advocates exploring the concept of networks connecting actors and events. On a similar vein, Rocheleau (2008:724) believes that political ecology has moved away from 'chains of explanation' to more complex 'webs of relation' with an emphasis on multiple identities and situated knowledges stemming from feminist post-structural theory, but still attributes the new directions in political ecology to the inspiration of Blaikie. While preferring 'chains of explanation' over 'webs of relation', I use aspects of both, and follow Blaikie's approach in being open to diverse literatures. As

Muldavin (2008: 695) outlines: 'Blaikie was willing to engage and integrate a broad range of knowledges into his theorizing, fieldwork, policy work … [and] writing'. In this research I proceed in this vein, but the challenge remains to produce political and ecological accounts which stand up to the rigours of 'critical scrutiny of their explanatory traction, their purchase on political leverage, and their ability to clarify rather than obscure the important and troubling conditions of the hybrid world around us' (Robbins & Marks, 2010: 192).

We have here multiple narratives involving humans (farmers, vets, and state policy officials); non-human life (disease, bacteria, cattle, badgers and deer); and technological materials (diagnostic test for TB). Considered together, this assemblage constitutes a First World agricultural political ecology, simultaneously 'political, biopolitical and material' (Bakker, 2012) across scales ranging from the microscopic to the global (Brown & Purcell, 2005; Engel-Di Mauro, 2009). Such a practice of political ecology stems from an enquiry 'entailing multiple changes of scale, perspective, orientation' which generate 'a perpetual state of motion in our concepts and our thoughts' (Harvey, 1996: 58). In adopting this stance, we can not only provide chains of explanation, but also explore 'potentialities' and 'possible worlds' (Harvey, 1996: 56). Or, as Robbins (2012a: 99) puts it: 'Political ecology seeks not simply to be retrospective or reactive, but to be progressive'. It is not enough simply to explain; there must also be an attempt to plot a way forward.

Deconstructing and reframing TB narratives

Ethnographic methodologies provide a way to construct these explanations and potential solutions, for *people* are at the centre of TB eradication efforts. McCarthy (2002) sees fieldwork using case studies and ethnographic methods as the best way to investigate First World problems. An ethnographic approach is also supported by Neumann (2005:42) to understand the 'roots of conflict' in environmental disputes. Moving from my previous viewing point in quantitative veterinary epidemiology, and as will be discussed further in Chapter 2, I replace the 'gaze from the database' to provide the 'gaze from the ground' (Leach & Scoones, 2013: 15) and from above (Robbins, 2002). I provide qualitative ethnographic narratives of TB to conjoin the normatively ascendant statistical and quantitative perspectives on state disease control policy.

According to Leach and Dry (2010: 5), 'narratives – in constructing disease issues in particular ways – frequently also construct people and populations, labelling and making moral judgements about them', meaning that they are also 'intertwined with issues of power and social justice'. A hallmark of political ecology is the deconstruction of 'grand narratives': challenging prevailing wisdoms (Leach & Mearns, 1996); and debunking myths, particularly where the marginalized have been accused of 'ignorance' (Dove, 1983). Investigating narratives often involves looking at the present in the context of the past (Davis, 2009). Whether the narratives are centred on desertification of the Maghreb (Davis, 2007), deforestation in West Africa (Fairhead & Leach, 1996), or global disease epidemics (Dry and Leach, 2010a), political ecologists have succeeded in 'wielding the intellectual hatchet' (Robbins, 2012a: 98) to prevailing narratives to reframe them (e.g. Fairhead & Leach, 1998). This is particularly appropriate for subject areas which are uncertain or controversial, and where rhetoric and myth abounds in relation to disease (Roe, 1989; Craddock, 1995; Tadros, 2010).

Narratives are used in everyday life and in policy making as a way to '[make] sense of an uncertain, complex and contested world' (Blaikie, 2009: 4). How a disease narrative is framed of course depends on the vantage point: 'Within alternative narratives, the dynamics of a given disease, what counts as a problem, and to whom, can vary greatly' (Leach & Dry, 2010: 5). As Hajer (1995: 63) asserts, 'story-lines fulfil an essential role in the clustering of knowledge, the positioning of actors, and, ultimately, in the creation of coalitions of actors of a given domain'. Particularly fitting within a political ecology framework, with its emphasis on the concept of marginality (Watts & Peet, 2004), are the narratives from the fringes – those whose voices may not otherwise be heard. Seen from that perspective, new storylines are useful political devices which can overcome fragmentation and promote unity between the actors on a given stage (Hajer, 1995).

TB has its own stock of narratives and 'commonplaces' (Myers & Macnaghten, 1998) on the disease and its causation. These tend to be reductionist, and based on accusation and denigration: blaming farmers and their lack of attention to good biosecurity practices; blaming badgers; or blaming the state veterinary authorities for their failure to administer a 'successful' programme. In this way, moral judgements and accusations can be made and targeted at various levels and actors within the TB network. It is time for the creation of new storylines and a holistic reframing of TB eradication.

Engaging with policy

The call to investigate TB in NI originates from the state, and this research is commissioned and 'political'. The PhD is funded by the Department of Agriculture and Rural Development (DARD) in NI as part of its 'Evidence and Innovation Strategy (2009-2013)', and an objective is to guide TB eradication policy for the future.

Castree and Braun (1998:12) call for political ecology to 'draw out the political implications of its analyses'. Walker (2006: 382) however accuses political ecologists of being 'ambivalent and divided' about *policy,* and with a tendency to engage in scholarly debates with each other rather than with those outside of the academy. Even if there remains freedom to critique policy, Walker (2006: 392) points out that 'critique by itself is not engagement.' More work is required to move political ecology research from the 'verdant but largely peripheral pastures of academia' to the centre of public debate and policy development (Walker, 2006: 392). Rocheleau (2008: 718) suggests that Piers Blaikie has been at the vanguard of 'creating space for policy-relevant PE research that seeks to inform national and international policy as well as practical and technical problem solving efforts'.

Political ecologists generally conduct research into topics of interest because they care about environmental degradation and social injustice, and want to change things for the better (Taylor, 2011), as I do through this research. According to Blaikie (2008: 768), political ecologists have tended to avoid engagement with developing and improving policy, perhaps fearful of being compromised, and of losing the ability to critique and retain 'ideological purity'. Blaikie strongly encourages such work, and this emphasis has been present throughout his career (Blaikie, 1975; Blaikie, 2009; Blaikie, 2012). He is keen to see research being transferred to the policy sphere, but warns that it can be risky both for the researcher and the researched. For example, senior bureaucrats and policy makers may be unimpressed by being criticised in research findings, and unwilling to fund further research if they have a negative experience (Blaikie, 2008). A failure on the part of the researcher to provide clearly-defined policy suggestions is also likely to provoke 'irascible responses' (Blaikie, 2008: 769).

There is also a need to be aware of potential gaps between policy rhetoric and grounded reality. From Blaikie's experience, 'in many cases, outcomes of policy and what happens on the ground may bear little resemblance to the intentions of those who shape and draft policy documents' (Blaikie, 2009: 5). He acknowledges the multiplicity of viewpoints and competing objectives that the various actors involved in enacting or responding to policy may have (Blaikie, 2009). Even though policy makers may formulate policy in 'good faith' and with rational professional objectives, 'evasions … ambiguities, and contested strategies' (Blaikie, 2009: 5) may be the response. This demonstrates the importance of 'tak[ing] into account the decisions and actions being made by others on the ground outside the formal policy process'; 'other voices [who] may not be heard and … unable to join the negotiating table …' (Blaikie, 2009: 5), with a particular emphasis on local knowledge (Blaike *et al.*, 1997). This fits with 'understanding the context in which actors and their narratives work and have their day-to-day lives in terms of the structures, institutions and the relationships in which the actors are involved' (Blaikie, 2009:5). It can be a challenging task, for the policy process and its narratives is always unfolding and changing (Blaikie, 2009); policy itself a dialectical process of 'becoming'.

Despite these qualifications, when carefully considered and judiciously applied, political ecology has the power to produce 'real-world solutions' (Doolittle, 2010: 78). It is not enough to merely understand the 'stories of which we are a part', but we must also 'take a view on what should be done about them' (Blaikie, 1996: 83). In other words, the task is to produce a 'useful' political ecology which engages both inside and outside of the academy (Blaikie, 2012). But before providing policy recommendations, the ethnographic political ecologist's task is to 'situate research in context, describe before explaining, and avoiding the tendency to jump to policy recommendations. It requires starting with everyday practices …' (Lawhon *et al.*, 2014: 506). The policy recommendations are presented in Chapter 9, but before that there is much to describe and explain concerning the past and present everyday lives and ecologies of TB eradication in NI.

Outline of the thesis

The thesis begins in Chapter 2 with the research methodology, foregrounding my positionality as a *veterinary* geographer. Chapters 3-8 present the empirical findings of the research in a chain of explanation, and as described in Chapter 2, each chapter will answer a different subsidiary research question to form a link in the chain exploring why TB has not yet been eradicated in NI. Chapter 3, based primarily on archival research, provides the historical context of state efforts to eradicate TB which began in earnest in the 1950s. Chapter 4 describes how farmers are key actors in TB eradication and investigates the context within which they farm today, particularly how their everyday political economies and cultures shape their presents and futures. Chapter 5 centres on TB as a disease with multiple framings on the frontline of eradication, and Chapter 6 looks at the TB test which vets use to diagnose and make the disease known through measurement and the performance of science in the field. Chapter 7 explains the complex ecologies of TB – how and why it continues to spread within the cattle population of NI, and shows how this is influenced by the political economy of modern intensive farming. Chapter 8 concentrates on how TB may be governed, and shows that the governance of TB is much more than seeking to eliminate a bacterium. The thesis then concludes in Chapter 9 with an overall analysis of whether this political ecology of TB works and is useful, and provides recommendations to policy makers.

Like many environmental problems, TB undoubtedly has multiple causes which interact in a complex web of relation and there is no single root cause or 'silver bullet' solution (White *et al.*, 2008). Ellis (1996) describes the search for root causes in environmental problems as 'highly charged,' and often the source of disagreement and dispute, but he proposes that such conflict can be the 'crucible of synthesis' when a more holistic view of the problem is taken. My intention is not therefore to determine or describe 'some essential root cause' of TB, but rather to provide 'a fuller assessment of the related, complex, and multiple origins' (Ellis, 1996: 268) of the disease and efforts to control or eradicate it. As with environmental problems which are ‘a manifestation of broader political and economic forces’ (Bryant & Bailey, 1997: 3), the failure to eradicate TB cannot simplistically be viewed as an example of many years of inadequate state policy.

Added to that, I would suggest that TB demonstrates the inherent ‘instability of matter’ (Braun, 2008: 677) when humans attempt to dominate and suppress nature, whether that be in the form of bacteria, badgers or bovines within ecological landscapes. Perkins (2007: 1153) suggests that such problems call for investigation: ‘The damage ‘rogue’ organisms cause compels further theorization of the proliferation of non-humans within capitalist urban political economies.’ That does not mean that efforts to eradicate pathogenic bacteria should be abandoned, but they must be approached with humility and awareness of the limitations of the scientific paradigm that technological prowess will always win through. Eradicating TB would benefit humankind, but also save the premature and unproductive slaughter of thousands of cattle in NI in the years to come: it is a worthy ambition.

Rather than an over-arching grand narrative, perhaps the links in this chain of explanation can be regarded as mini-narratives or images on an ‘academic pinboard’ (Law, 2002: 188-203) of everyday life and practice in the world of TB. Enticott (2001: 161), using an alternative analogy, suggests that ‘if nature is to be effectively governed, then it is therefore necessary to approach these problems with a large net and attempt to piece together all the factors involved.’ In short, the aim is to create some kind of order out of what can be described as a complex and messy situation where hope of progress is lacking on the frontline. We proceed with due caution, but confident that there are indeed stories to be told.

Chapter 2: Methodology: creating a chain of explanation

This chapter explains the design and process for this research and introduces the research questions used to construct the chain of explanation. It begins with autoethnography detailing my path to the PhD, foregrounding my positionality as a vet and farmer's son. Next, there is a discussion of the typical methods used in political ecology research. Then, after an in-depth discussion of the data generation and analysis which I used, I look reflexively at how my positionality affected the research process and the findings which are presented in this thesis.

The path to a PhD

Being rural, suggest Farmer *et al.* (2012), is a distinct advantage for conducting rural research. In gaining easier access, having more credibility, and being able to empathise more readily with those being researched, they argue the benefits of such positionality in the qualitative research of the rural. Bennett (2006) likewise thinks that her farming background fuelled interest and eased access for fieldwork down on the farm. My own upbringing, career and research theme are all rural, and authenticated my research into TB as an academic human geographer. The embodied personal knowledge and experience of livestock farming and TB eradication created a bond with my research participants, and I was immersed in the subjects we discussed together. We all cared about the subject and object of the research.

I was born into a farming family. My father is a farmer, as my grandfather and great-grandfather were before him. I was reared in the mid-Antrim countryside surrounded by rolling green pastures and half a mile from the road. Most of our pasture land was ten miles away in the shadow of Slemish Mountain, according to tradition once the place where Patrick, Ireland's patron saint, looked after sheep. The farm was a wonderful place to grow up, but despite the depiction of rural idyll, my earliest memory of farming life is of fear, for around the age of three a sow chased me across the farm yard. Overwhelmed by the sight of this fast-approaching porcine body, and in a state of terror, I beat a hasty retreat to the sanctuary of my mother's arms. Pig rearing, though, was only a minor enterprise on our farm, for my father loved cattle above all other farm species. We kept beef suckler cows to produce calves, born between March and April, and sold in November for someone else to fatten for slaughter. This was (and remains) the mainstay of the farm business.

There was a strong sense of community amongst the farms in the local area. Neighbours were always on hand to help at hay time and when cows got into obstetric difficulties beyond the ken of my father to resolve. Many fine summer days were spent gathering potatoes on farms in the district – a way of helping, but also a welcome source of income, most of which, influenced by my grandfather, I invested in the state privatizations of the day. Surrounded by those of kindred spirits, we felt part of a hard-working and vibrant agricultural community.

Inviting the vet to the farm to see a sick animal was a notable event in farming life. I remember Liam the vet driving a red Citroën Dyane and smoking a pipe. He was an 'old school' vet who worked on his own, and had been my grandfather's vet in earlier times. Drawing on the pipe appeared to allow time for reflection on particularly puzzling cases. The farming community greatly respected him, for he 'knew' cattle more than most. After he died, we changed to a neighbouring practice which was on a grander scale and more up-to-date with the latest medications and techniques. I remember looking on with wonder at the car boots packed with drugs and equipment, just enough room left for the boots and overalls squeezed into the corner.

The annual TB test of the herd was a significant date on the calendar, and tests in school holidays or on Saturdays meant I was in the thick of the action. The cattle in our yard were housed in small groups in multiple sheds, and each had to be released in turn and taken to the cattle 'crush' – the pen where they were restrained for the test. I remember my father instructing whatever vet was performing the test to hide until the cattle were safely restrained, for nothing was surer to raise their state of nervous anxiety than the sight and sound of a stranger bedecked in waterproof clothing. One particular cow ('Ginger') always made a valiant escape attempt, once flattening the cattle crush wall on the way to freedom. The vets had their own skills for dealing with such resistance to the test, and one older vet was particularly adept in quietly going about his work with minimal fuss. I admired his skill, but wondered if the alcohol on his breath was the key to smoothing the process for both man and beast. Another testing vet was memorable for his love of horse racing. Gaps in the test were an opportunity to slip into the house to catch the latest from Cheltenham or Aintree. We were fortunate never to have a TB breakdown, although there were occasional inconclusive animals which needed a re-test six weeks later. TB rarely came into our locale, and when it did, it soon departed.

The farm had its share of wildlife co-habiting with our cattle in the fields and surrounding hedgerows. Amongst these species were badgers, seen only at night when disturbed on the laneway by the headlights of the car. They bounded up the lane until they spotted a hole in the hedge to dive from the beams trained upon them. In addition to these rare sightings in the flesh, we saw their sett holes, and tracks through long grass and at farm boundaries - hairs caught on the lower strands of barbed wire were evidence of their passage. Badgers were neither loathed nor loved – they were just there.

At the age of fourteen I decided to pursue a career as a vet and after work-shadowing at the local veterinary practice for a few days my career choice was confirmed. After vet school in Glasgow, the school of James Herriot, I started my career as a mixed practice vet in east Antrim in 1997, and soon I was the one with the waterproof overalls and tuberculin syringes hiding behind crush walls, waiting until all were restrained for the test. I tried to emulate the skills of the old vet who moved quietly and methodically along the line of cattle, but without the alcohol, and with a steadier hand.

From my days in private practice I moved on to join the Veterinary Service of the Department of Agriculture and Rural Development (DARD), where TB control became my main occupation: testing positive herds and inconclusive animals and investigating outbreaks. I met many farmers, becoming particularly acquainted with those who had repeated TB breakdowns or inconclusive animals, and also those with a bias towards breaking the rules. I prepared prosecution files for the state in the most serious cases. In a different vein, I worked in abattoirs where meat inspectors checked for lesions suggestive of the disease in bovine carcasses, another significant cog in the TB surveillance machine. I later transferred to DARD headquarters to study TB as a veterinary epidemiologist in a unit generating scientific (mainly quantitative) research on the disease, and providing policy recommendations for its more effective control.

Working on the frontline of the farm and abattoir, and more recently in the hinterlands of epidemiological research, the majority of my professional career has therefore been focused on TB eradication. To borrow Paxson's (2008) phrase, my job has been to exercise 'microbiopolitical control.' My commission has been to detect and eradicate this infectious disease, and ultimately the *M. bovis* bacteria which cause it. To quote Hird (2009: 26): 'I am schooled in recognizing my meetings with bacteria as military encounters' and the 'pathogen matrix' has overwhelmingly defined the parameters of my meetings with the TB bacterium. Indeed, I am fascinated with pathogens and disease - as a veterinary surgeon, the study, prevention and eradication of disease was (and is) my *raison d'être*. Rather than living *with* in some form of cordial relation (Hinchliffe & Whatmore, 2006), my objective has been to investigate whether and how it is possible to live *without* TB, to create a 'hoped-for-absence rather than relation' with this non-human other (Ginn, 2013: 7).

In preparation of a doctoral thesis my objective in TB eradication seems a long way from hiding behind crush walls, injecting tuberculin, and measuring fluid swellings in bovine skin. My task is more akin to the late Seamus Heaney's reflection on the difference between his work and the earthy spade work of his farming father: 'Between my finger and my thumb the squat pen rests. I'll dig with it' (Heaney, 1980: 11).

Research questions

'Questioning builds a way' stated Heidegger (1977a:3), and my aim is to build a way of understanding, to uncover the hinterland (Law, 2004: 32-35) of TB eradication through interviewing the actors involved and to represent what they say through my writing. My life history has given me a research topic which I 'care enough about to study' (Lofland & Lofland, 1995:11). I want this research to progress the debate, and to help the drive towards disease eradication. Indeed, to reposition myself as a natural scientist becoming a social scientist, I have taken another approach in the hope of being able to make 'a political intervention in a situation of impasse' (Lane *et al*., 2011: 15). Bearing in mind the relations involved in the TB network, and using an ethnographic approach to researching TB, the primary research questions are as follows:

> Firstly, why has TB not been eradicated from NI despite a comprehensive state control strategy spanning more than five decades?

Secondly, approaching the problem from a political ecology perspective, can such a qualitative ethnographic investigation of the problem provide critical analysis and suggest workable policy solutions?

To help answer these questions, the following subsidiary research questions are also highly relevant, and each of the following six chapters of the thesis deals with one of them:

What is the historical context for the present TB eradication programme in NI? (Chapter 3)

Where does TB fit within the political, ecological and economic complexities of everyday farming life in NI today? (Chapter 4)

What is TB, and how do its behaviours as a disease frame lay and expert knowledges of the disease? (Chapter 5)

What influences do the technologies of TB testing of cattle have on programme success and future prospects? (Chapter 6)

What are the ecologies of TB, and how does it spread between cattle within the disease landscape in NI? (Chapter 7)

What are the key issues affecting the governance of the TB eradication programme, and where are the frictions and slippages? (Chapter 8)

Veterinary geographies of TB

Geography, with its 'theme of connectedness, of the hanging-togetherness-of-things' (Livingstone, 1992a:173), is the perfect medium for exploring such a problem as TB. Although first impressions may suggest a huge gulf between veterinary science and human geography, this is not so far removed from my previous life as an epidemiologist, for as one interviewee suggested, ‘epidemiology brings everything together’ (Int A45, state vet). As a vet within geography I can particularly ‘interrogate the “more-than-human” constitution of the rural’ (Woods, 2009: 852). In doing so, I share political ecologist and vet Diana Davis’ views on the benefits of marrying veterinary science with geography in interdisciplinary research. My veterinary training and experience allows me to ‘ask old questions in new ways to elicit more thorough answers’, creating what she calls ‘veterinary geography’ (Davis, 2001: 465). As well as the old, I will also ask new questions and investigate issues which perhaps the key actors in the TB story have never thought about before, with the aim of illuminating the crevices and cracks in effective disease control.

Having worked as a veterinary epidemiologist in a unit researching TB almost exclusively by quantitative methodologies, I came to accept that these were by no means providing all the answers to the problem of why the disease persists, nor what to do about it. A visiting US-UK Fulbright scholarship at Mississippi State University in 2010 introduced me to qualitative research, and with collaboration between the veterinary and social science faculties we investigated factors affecting diagnostic sample submission to veterinary laboratories. Using a focus group methodology with private veterinary practitioners, the research experience was a very positive and fruitful one (published as Robinson *et al.*, 2012a; Robinson & Epperson, 2013). I was convinced of the merits of qualitative research applied to topics of veterinary science and epidemiology, and open to crossing the divide to the ‘other side.’

Even though there may be a dividing line, these are not mutually exclusive positions, and Glaser and Strauss (2008) argue a place for both qualitative and quantitative research in generating and verifying approaches to the resolution of research problems; *both* forms of data are required. Similarly, Porter (2006) posits linking epidemiology with anthropology, the quantitative and the qualitative, to provide more holistic and joined-up thinking in researching public health issues. Realizing that quantitative methods and scientific rationale will only capture some of the 'truths' of the problem (Hamilton, 2012), I therefore wanted to expand my approach and research different aspects of TB. For me, qualitative research was needed to know TB in different ways to that of quantitative methodologies, and particularly to ask the 'why?' questions. As Sayre (2004: 668) points out, 'with its greater flexibility and attention to context, qualitative research can reveal social, historical, political, and economic factors that … have eluded quantitative studies'.

This is being increasingly realised within veterinary (natural) science, with an increasing recognition of the importance of, and calls for more, social science to better understand animal disease governance and policymaking (e.g. Fish *et al.*, 2011; Wilkinson *et al.*, 2011; Christley *et al.*, 2013), including for TB (Godfray *et al.*, 2013; Pfeiffer, 2013; Cowie *et al.*, 2014). As Donaldson *et al.* (2010: 1522) suggest, these 'calls for interdisciplinarity can be seen as a response to messy realities', and perhaps even cries for help from natural scientists charged with resolving increasingly complex muddles of the human and the non-human in situations of animal disease control. The questions being raised, especially by policy makers, seek to cope with the interference and heterogeneity in disease control networks (Hinchliffe & Bingham, 2008) which confuse and perplex. Thompson and Warburton (1985: 116) discuss the 'science of messes', and emphasize that 'the most important thing for the scientist who ventures into this region is that he be aware that he [*sic*] is entering it'.

Law (2004:7) argues that conventional research methods have their place, but in a complex world there must be room for creative imagination. In thinking about how to engage, he aims to 'broaden method, to subvert it, but also to remake it' (2004:9). This is particularly appropriate for TB, for TB is what Law might call a 'messy problem', and there is room to create 'methodologies for knowing mess' (Law, 2003: 3). I believe that I am answering Law's call for researching in new and imaginative ways: a vet who metamorphoses into a human geographer; a political ecologist who borrows from and plunders diverse literatures which may on the surface appear inchoate; and a quantitative epidemiologist who turns to ethnographic methods. In my defence, Law warns that 'simplicity … won't help us to understand mess' (Law, 2003: 3). As a newcomer without prior engagement with the discipline of geography, and in keeping with the mindset of Lowe and Ward (1997:270), I will therefore 'revel in theoretical and methodological diversity' in creating 'mess' among and within disciplines (Donaldson *et al.*, 2010). This, I argue, is a justifiable response to the messy complexity and hybridity of the subject and object of the research – understanding more of TB and the factors affecting its eradication.

For instance, despite their ontological divergences, there is still room for useful engagement between research informed by Actor-Network and assemblage theory with critical realist approaches (Elder-Vass, 2008; Sayer, 2013; Elder-Vass, 2014). Although critical realism may have lost popularity amongst human geographers today, Pratt (2013), discussing critical realist approaches, sees merit in engaging with such 'older' positions. Anderson *et al.* (2012: 213) suggest that assemblage theory is realist, and is a type of realism which can 'account for the diversity of entities in and of the world'. In situations of messiness, I would therefore advocate bringing different geographical literatures and vocabularies into conversation, for the nature of geography is always negotiated, and not fixed (Livingstone, 1992b). There is room for veterinary geography, and to borrow McFarlane's (2011: 205) phrase: 'There are several traditions and modes of thought being put to work'.

Political ecology and fieldwork

Turning more specifically to political ecology, scholars have likewise recognised that the scientific method is not enough to provide all the answers to complex environmental problems such as soil erosion and land degradation (Blaikie, 1985; Blaikie & Brookfield, 1987). There is a need within political ecology for 'hybrid' research which also explicitly incorporates the social, economic and the political dimensions of the problem in partnership with natural science explorations and explanations (Blaikie, 1989; Batterbury *et al.*, 1997; Forsyth, 1998; Zimmerer & Bassett, 2003). In doing so, Robbins (2012a: 85) thinks there are 'very few techniques, technologies, or analytics not used in political ecology'.

Some have accused the field of being incoherent as a result, but continuing in Carl Sauer's Berkeley School of Geography tradition, *fieldwork* continues to be a hallmark of political ecology: 'This empirical tradition sent researchers into the countryside … exploring the social world of people as expressed in their use of nature' (Robbins, 2012a: 37). Ethnography, once most closely associated with anthropology, is now increasingly used by political ecologists who use qualitative methods in the field to study and interact with research participants (St. Martin & Pavlovskaya, 2009). Aiming to gather the views from the ground, the task is to 'carry less powerful or local knowledge to the policy arena', but not 'romanticising' it just because of its ground-level origins (Batterbury *et al.*, 1997: 129). Democratizing knowledge of environmental problems is a laudable and important aim, but it does not mean that knowledge claims, from whatever source, are accepted uncritically (Batterbury *et al.*, 1997). Having generated empirical data in the field, political ecology may operate 'in the borderlands between analysis and action' (Robbins, 2012a: 85), and simultaneously 'constructs and deconstructs, criticises and defends, listens and argues' (Robbins, 2012a: 86).

These practices are of methodological significance. Political ecology, as outlined in Chapter 1, has power to dismantle and reassemble, to critique dominant narratives, and to provide new storylines. Despite this powerful potential for progress out of impasse, Robbins warns that: 'Balancing criticism and effective policy intervention – weighing political ecology's hatchet against its seed – is demonstrably difficult' (Robbins, 2012a: 60). Perhaps because of this inherent difficulty, especially in providing causal explanations for environmental problems, Robbins (2012a) cautions about making grandiose claims, and instead he encourages political ecologists to be restrained in the grandness of their conclusions, tending rather towards humility.

Political ecology as a field seems to attract conceptual and methodological controversy as it merges various ontological and epistemological knowledges together in creative syntheses which may attract criticism from philosophical and methodological purists (see Robbins, 2012a: 103-154). Importantly, the overall task is to 'avoid the simplistic separation of science and politics … and the use of a priori notions of ecological causality and meaning' (Forsyth, 2003: 21). Fundamentally, our knowledge of the world is not infallible, but there is a world which exists outside of our knowledge of it, and it lends itself to being investigated and explained (Sayer, 1992). In common with the majority of political ecology scholarship, my research on TB is underpinned by this critical realist perspective, and its methodologies were influenced by this philosophy to thereby create a '*critical* political ecology' (Forsyth, 2003). Between hard realism on one side, and constructivism on the other, the research 'dwell[s] somewhere in between' (Robbins, 2012a: 125).

That being evident, and in line with a critical realist approach, it therefore 'sets itself the task of identifying and unravelling the diversity of underlying mechanisms' involved in the ongoing spread of TB, and assumes that these practices, processes and things are both biophysical and social (Jansen, 2009: 178). As described in Chapter 1, the aim is to follow Blaikie and Brookfield (1987) in providing a chain of explanation for the persistence of TB in NI. The assumption is made that despite the undoubted messiness and uncertainty, the failure to eradicate the disease has some knowable and rational explanations.

While the main focus is to provide insight into the human 'lifeworlds' of those involved in TB 'as ways to create knowledge that would inform change' (St. Martin & Pavlovskaya, 2009: 373); non-humans are always an integral and essential part of the ethnographic accounts. This creates 'a background animated by the material and sensory (and cognitive) capacities of human bodies and the liveliness, affordances and recalcitrances of non-human agency' (Roe & Greenhough, 2014: 54). As a vet, this is not new to me, for the human and the non-human always interact in the veterinary and agricultural assemblages with which I am so familiar.

My research utilized a plurality of qualitative approaches involving semi-structured interviews (mostly with individuals), focus groups and archival research. The non-humans could not speak, but the humans certainly spoke of them, and they (especially badgers) were an ever-present reality in many of the discussions. These methods were complementary, and I believe that they increased the explanatory power of the research by interviewing a range of stakeholders individually and in groups to provide a rich ethnographic account of TB from the participants on the ground. They uncovered the 'processes and meanings that undergird (the) sociospatial life' (Herbert, 2000:550) of TB in NI. The archives provided historical context for what came afterwards in the life of TB eradication.

I will firstly introduce interviewing and focus groups as methods for conducting fieldwork, and my rationales for using them. After describing the archival research, I will return to the logistics of the interviews later in the chapter, before reflecting on the interview process and my positionality as ethnographic insider/outsider, or indeed somewhere in-between. Despite the messiness of both subject and methods, the task is to create some kind of order from confusion, furthering knowledge and understanding of the complex problem that is TB, and suggesting what might be done to improve prospects for the future.

Semi-structured interviews

The main research methodology I used to further knowledge and understanding was the semi-structured interview. 'Interviewing …' states DeLyser and Sui (2014: 295) '… remains a vital and vibrant research method.' Reflecting the actors' understandings of their worlds, what is said, and how it is said, are important (Pratt, 1995). Individual in-depth interviews enable 'networks of relationships and ideas to be presented and qualified' (Hoggart *et al.*, 2002:205) and can be viewed as a collaboration between the interviewer and the interviewee (Valentine, 1999). Furthermore, Herod (1999) suggests that the researcher and the person being interviewed are 'co-partners in the production of knowledge about particular events and processes.' This was my experience of interviewing on TB, and I reflect on this later in the chapter.

Although participant observation is a traditional mainstay of ethnography (Crang & Cook, 2007), given my previous life experience I did not believe that it would help to answer my research questions, and the interviews and focus groups were tailored more appropriately towards my objectives. I was convinced that ethnographic enquiry would provide a depth and a richness which went beyond the quantitative; producing an enquiry which looked into crevices and cracks which are beyond the reach of numbers and statistics, beyond confidence limits and *p* values.

I used semi-structured interviews primarily with cattle farmers, private and state vets, and DARD policy officials to realise their vision of the world, and I in turn sought to reflexively re-present that vision in my interpretations and writings (Cloke, 1994), 'giv[ing] voice to cultures [of TB] which would otherwise [mostly] remain dumb' (Murdoch & Pratt, 1993: 422). The interviews were partly with a range of people that I had met previously or worked with in a professional capacity, or as part of my farming locale, but I also recruited farmers and vets that I had never met before. With approximately 20,000 cattle farmers in NI and about 300 vets involved in farm animal practice there was access to a large pool of potential interviewees. Through my previous career experiences and wide network of contacts within the agricultural industry and state veterinary service, I was confident in my ability to recruit a suitable sample. Before going into the field I was also hoping that my positionality would have a positive effect and would encourage participation in the research and facilitate the development of a rapport in the interview (Valentine, 2005) due to mutual understanding of the farming world.

As an experienced vet I did not come to interviewing as a complete novice, but my previous experiences of interviewing had been in very different contexts to that of the veterinary ethnographer. Gathering histories from the owner of a sick animal; investigating disease outbreaks on farms; gathering witness statements for prosecution files; or interviewing transgressive farmers under caution were all forms of interviewing in a previous life. The vital importance of listening as well as speaking, probing and observing and taking cues from body language were common to all. Now my task as the interviewing ethnographer of TB was a different one, but one I approached with great enthusiasm and eager anticipation.

Focus groups

If semi-structured interviews major on the individual, focus groups by contrast integrate pluralities of participants in the research endeavour. Focus groups are a form of group discussion typically involving between four and ten people, and are increasingly being used in qualitative social science and human geography research (Burgess *et al.*, 1988; Hopkins, 2007a; Macnaghten & Myers, 2007; Cameron, 2010), although are very seldom reported as a political ecology methodology. They originated in a contemporary social science context in psychotherapy and marketing research (Crang & Cook, 2007:90), and are especially useful to formulate ideas and provide orientation to a new field, or to triangulate findings in multi-methods research (Goss, 1996).

Skop (2006) argues that focus groups provide a platform for debate and give collective voice to participants. Focus groups therefore have the potential to provide different data from semi-structured interviews on the same topic, and the synergistic social interaction in a group setting forms a particular attraction (Kitzinger, 1994). Disagreements are often aired and debated in the course of the group discussion, allowing participants to defend or to reconsider their own position (Cameron, 2010) in a dialectical to-and-fro. This interaction between participants is a distinctive and productive feature of focus groups which cannot be achieved in semi-structured one-to-one interviews. For a controversial subject such as TB, I expected the interaction and conflicting views between participants to be a useful feature of the discussion. In addition to this defining characteristic of group interaction, they can give voice and empower seldom-heard voices, and Pini (2002), having successfully used the methodology herself, advocates their use in rural research. Personal experience of focus groups with private vets in Mississippi (Robinson *et al.*, 2012a) and NI (Robinson & Epperson, 2013) provided further evidence that focus groups were also enjoyable for both researcher and participants (Goss & Leinbach, 1996). The initial aim was to hold separate focus groups with private vets, state vets and farmers, but the private vet group did not materialise in the field setting.

Ethical considerations

This research received ethical approval from the Department of Geography at Durham University. All participants signed a consent form and agreed to have their interview electronically recorded. I explained to all interviewees the purpose and form of the research, and went through the consent form orally, also encouraging them to read it for themselves before signing. In explaining the nature of the consent being given by each participant, I pointed out that the findings of the research would be written up as a thesis, a copy of which would be provided to DARD as the sponsors of the research. I also explained that the findings and quotations from the research may be published in academic journals; presented orally and in posters at conferences and to other interested organisations and audiences; and used for teaching and research training purposes. Participants had the right to withdraw their contribution from the research during or after the interview.

The interview transcripts were tagged with a code number and the category of interviewee or institutional affiliation e.g. 'Int A12, dairy farmer' or 'Int A42, DARD vet'. Participants were assured of confidentiality if they chose to remain anonymous. The vast majority preferred anonymity, but a few said that they did not mind whether they were anonymous or not. To avoid drawing attention to very few specific named individuals I made the decision to treat all interviewees as anonymous when citing interview excerpts in the thesis. Further consideration of ethical issues will be given later in this chapter as part of the reflexivity on the research and my positionality.

Visiting the archives - historical scene-setting

Although the main focus of my fieldwork was interviewing, I also conducted archive research in the Public Records Office of Northern Ireland (PRONI) in Belfast. Archival research is often used as a qualitative geography research methodology (Withers, 2002; Lorimer, 2010; Roche, 2010), and is commonly used in political ecology fieldwork either on its own or as part of a multi-method research strategy (Fairhead & Leach, 1996; Davis, 2007; Davis, 2009, Doolittle, 2010).

Conscious that few people today would know the details of TB policy forty years ago my objective was to discover more of the historical background of the TB eradication programme. Using archived Civil Service files, my aim was to provide some context for the present-day situation using the documented records of the past. Only three files from the Department of Agriculture seemed relevant to my quest. A file named 'TB policy, Part 1, 1972 - 1977' (AG/33/30) was the most valuable source of information, and forms the basis for most of the material presented in Chapter 3. Another file labelled 'TB policy and legislation 1956-1974' (AG/33/41) surprisingly did not contain any material of interest, and another on the 'Adoption of tuberculin 1971-1976' (AG/33/47) was of very limited value. Due to the 30-year rule preventing public access to more recent state files I was unable to source any material from the 1980s from PRONI, but I acquired a 1985 document written by a former DARD official (Russell, 1985). The most valuable source of historical material, the DARD archives held at headquarters in Belfast, were completely destroyed in a flooding incident in 2012, just a few months before I was due to start my fieldwork.

I made two visits to PRONI, and these were my first ever forays into archival research. These investigations were on the last week of my fieldwork, and perhaps should have been earlier in the process. The interviews conducted to that point had stimulated a curiosity to know more of how we had come to the situation of the present. I had no idea what to expect within the files, and I was excited by the prospects of revealing ‘secrets awaiting discovery’ (Lorimer, 2010: 248) and ‘grub-up long forgotten facts’ (Lorimer, 2010: 251) for the present generation. All was new and shiny in the PRONI building, itself standing in the shadow of history on the banks of the River Lagan, near the shipyard where the Titanic was built. I was excited by the prospects of delving into yellowed and dog-eared policy conversations from around the time of my birth. The only window into what was lurking behind the scenes was the PRONI electronic database, and having searched online, ordered my files, and collected my queuing ticket, I dutifully waited for the files to be delivered across the counter.

Armed with my pencil and notepad, I remember the feeling of delight as I tucked into the contents. It was exciting to read the debates on TB amongst state vets and policy makers in the 1970s, finding they echoed many of the debates of the present and recent past. At last I was receiving some clues as to what had gone before, often a source of personal intrigue and mystery. This material provided useful background for my chain of explanation as to why TB eradication has yet to be achieved, but I could be accused of coming hastily to the archives and underestimating their complexity (Harris, 2001). In my defence, my research was not primarily a work of historical geography, but rather an ethnographic account of the present and prospects for the future, and the archival research was akin to ‘scene-setting’.

I made notes, paid for photocopies, and left – mission accomplished. But these neatly type-written reports, minutes, memos (opened with stiff salutations such as ‘Dear Green’) and voices from the past could not fully convey the emotion and tone of the discussions they described, and there seemed to be fewer documents than I would have expected. I wondered what had been sanitised in what was presented and what else had been written by hand and articulated through speech but not filed for future scrutiny. I recognised very few of the names recorded as participants, and the respectful formality of these Civil Servants' texts did not fully bring the subject matter to life. For that, I would have to rely on imagination and on the spoken word in the field of the present, letting the living work and breathe life into the present and, to a more limited extent, the past. In the mould of Harris (2001: 328), fieldwork in the world would mean 'to get out into it, look hard at it, ask questions about it, and grapple with the conundrums so presented'. The archival research proved valuable, but the policy landscape of the 1970s becomes part of a 'succession of presents' (Harris, 2001: 330), continually being reworked and changed, albeit with a thread of continuity running from the past to the here-and-now. This would greatly enrich and enliven the 'personal archive' (Withers, 2002: 305) of knowledge which I had created and carried within myself.

Interview and focus group logistics

In sampling for interviewees, my aim was to search for heterogeneous and 'information-rich' cases (Baxter & Eyles, 1997) using mixed sampling techniques to increase the trustworthiness of my findings (Baxter & Eyles, 1999), and I was 'an active sampler of theoretically relevant data' (Glaser & Strauss, 2008: 58). The interviews were all one-off interviews, as farmers and vets work long and irregular hours, and I did not anticipate any being willing to spend more than an hour being interviewed. This proved to be mostly the case in the field.

In total, 86 people participated in the research across 62 interviews. This total included 47 farmers; 30 vets (17 private, 13 state); 5 farmers' wives; 1 policy maker; 1 Member of the European Parliament (MEP); 1 research scientist; and 1 Ulster Farmers' Union (UFU) official. If the age of the participant was not asked or provided, an age was estimated. The approximate average age of the 47 farmers was 50 years (range 24-71), and approximately 49 years (range 24-65) for the 30 vets who were interviewed. The majority of the semi-structured interviews were one-to-one, but there were multi-person interviews with both farmers and vets (see Table 1 for breakdown), and two focus groups (one made up of state vets and the other of farmers). The multiple-person interviews with the farmers included their family members, particularly sons or the wife of the farmer being interviewed.

Table 1: Breakdown of number of persons interviewed simultaneously by category (excluding focus groups)

No. of persons interviewed	Farmer interviews	Vet interviews
1	31	14
2	2	4
3	3	1
4	1	0
Totals	37	19

The interviews were conducted between September 2012 and May 2013, and involved four intensive fieldwork trips to NI from Durham with multiple interviews per day at roughly monthly intervals until just after Christmas, with one final return visit in May 2013 for the last round of interviews. By this stage I believed that based on the task being *theoretical* rather than *statistical* sampling, 'saturation' had been reached, but 'making the theoretically sensitive judgment about saturation is never precise' (Glaser & Strauss, 2008: 64). The average length of interview was 42 minutes (range 18 – 83 minutes), providing a total of 43.5 hours of interviews. I transcribed all of it, producing 374, 396 words of transcript.

For administrative purposes within the Veterinary Service of DARD, NI is divided into ten divisions controlled by ten divisional veterinary offices (DVOs) (Figure 1). The farmer and private vet interviews were concentrated in two divisions - Ballymena division (traditionally lower TB herd incidence - 5.19% in 2012 –

lowest in NI), and Newtownards division (traditionally higher TB herd incidence - 11.32% in 2012 – highest in NI). I had grown up in the Ballymena division, and worked there as a DARD vet for almost eight years, and as a private practitioner for one year. I worked in the Newtownards division as DARD vet for three months on a temporary transfer in 2000, but did not know any farmers, and only a few private vets in that division. Although the majority of the farmer and private vet interviews farmed or worked in these two divisions (41 interviews), additional interviews were conducted with others from the Coleraine, Dungannon, Mallusk and Omagh divisions. The state vets interviewed represented the Newtownards, Ballymena, Armagh, Londonderry, Omagh and Enniskillen divisions, and also DARD headquarters in Belfast.

The sampling in both main areas was purposive to select a range of farmers who had experience of TB in their herds and others who had not. Although a gatekeeper - a private vet - selected the farmers in the Newtownards division from his client base, this was according to the same criteria. There was a spread between dairy farmers and beef farmers, mostly full-time farmers with some part-time, and of varying herd sizes. I was interested to see how my positionality played out with farmers who knew me as an ex-DARD employee who had visited their farm, and those who had never met me before, and whether this would change the dynamic of the interview. By choosing farmers from an area where I worked before, I felt that I could also better choose a selection of personality and attitude types, ranging from those who had welcomed my veterinary advice to those who were resistant to what they believed to be unwelcome state interference.

Figure 1: Divisional Veterinary Offices in NI (main study areas in yellow)

Pilot interviews

Before I started the fieldwork I met with two farmer friends (one beef, one dairy) and a retired vet during the Christmas holidays in the first year of my PhD (early January 2012) and had informal and unrecorded discussions on some of the themes I thought I might cover in later interviews. These informal conversations gave me further ideas of how I might approach the interviewing process. The retired vet made an initial approach to someone I could interview, a contact which opened a door to a valuable interview nearly a year later; the fireside chat on a cold winter's morning bore unexpected fruit.

Pile (1990:26) suggested that it took time to 'fuse the horizons of understanding' and develop trust and understanding between the researcher and the researched, and he therefore used a multiple-visit approach in his research with farmers in England. I was requiring this fusion of understanding to occur in a single interview, premised on my prior acquaintances with the interviewees acting as an enabling bridge to acquire rich and insightful data much more quickly. I wanted to trial my interview questions, but also to trial methods of arranging the interviews and assess how my positionality as a vet may affect my interviewees' willingness to engage.

The first fieldwork trip in September 2012 was a pilot in the Ballymena division, and involved six interviews with farmers. They were all in the local area where I had grown up and worked as a state vet. I had met four of the farmers before - one was a distant family relation - but the other two had never met me before. I started off with farmers who were more local to my parental home and these were also farmers that I knew reasonably well, allowing me to have a gentler introduction to ethnographic interviewing. I arranged four of the interviews by prior appointment, but for two of them I turned up without prior arrangement and was able to conduct the interview immediately. I found that they were very willing to engage and were interested in the project. Three of them had experienced TB breakdowns in the recent past.

The interviews were semi-structured, verging towards the unstructured. They were deliberately relaxed and conversational, and I tended to begin by asking the farmers to describe their farm, which seemed an easy introduction for them. I found that the key to arranging interviews with farmers was not to arrange them too far in advance, for the unexpected twists and turns of everyday farming life meant that the present was the only certainty. I interviewed at all times of the day and night, beginning at 9 am after morning milking was complete and breakfast had been consumed, or interviewing late into the evening, in several cases approaching midnight. The rhythms of the farming day dictated when a farmer had some down-time in a hectic schedule. All sacrificed valuable time to speak to me.

I transcribed the interviews, carried out preliminary analysis, and discussed these pilot interviews with my PhD supervisors before returning to the field. I was pleased with how the pilot interviews had gone, but I adjusted my questions slightly and added new questions, particularly on attitudes to risk and biosecurity, for the next batch of interviews in October 2012. The pilot had allowed me to refine my style of questioning, and I dispensed with notes and a list of questions afterwards, having memorized the types of questions I then wanted to pursue, and being much more confident in my ability to steer a successful path through subsequent interviews.

Returning to the field

For the October fieldwork I spent four days in the Ballymena division, and one in the Newtownards division. Flying into NI on a Monday morning, hiring a car for the week, and flying out again on the Friday evening, I felt like a 'proper' ethnographer travelling to a far-flung land, despite the flight being only 35 minutes! I conducted 22 interviews in five days by working throughout the day and into the evenings. The first day of the week was spent driving around farms asking for interviews and arranging the schedule for the rest of the week. I knew all of these farmers, but had not met most of them for over five years. I therefore felt that a personal visit to discuss the purpose of the interview would be more successful than cold calling, and this method worked very well. Again there were no refusals, and a few interviewees were able to conduct the interview on-the-spot. One farmer told me that I would have no trouble acquiring participants as 'I was very well liked round here' (Int A12, dairy farmer). This emphasized to me the importance of trust and rapport with interviewees, and personality may have played a part in facilitating access and is an aspect of positionality in fieldwork which is often overlooked (see Moser, 2008). Despite the fact that I had met most of them before in my capacity as a state veterinary inspector this did not appear to be a barrier to engagement in the research process for a difficult and controversial subject such as TB. I deliberately visited some farmers who I felt would have been suspicious of speaking to a former state vet, 'on the edge' with respect to complying with the law, and with whom I did not feel that there was a strong rapport from my time as their local state vet. Again there was a warm welcome, and they did not appear to hold back in voicing their opinions and criticisms of the government. Perhaps they welcomed the chance to give vent to their frustrations with someone who formerly represented 'the enemy'.

One farmer suggested I should speak to one of his neighbours in another division who had experienced a prolonged TB breakdown, and he telephoned him and set up the interview – a successful example of 'snowball' sampling (Noy, 2008). I also interviewed three private vets in the Ballymena division, one of whom I suspected would not participate because of our previous experiences in my role as a state vet, but he agreed to be interviewed, and seemed intrigued and curious as to why I would want to interview him. The fifth day of this October week was spent in the Newtownards division, and the interviews were all set up by a private vet in the area who invited five clients farming in a TB 'hotspot' area. I knew none of these farmers, but I was well received by all. The importance of the gatekeeper was evident - they spoke highly of him and it seemed that for some of them at least, their willingness to participate was as an acknowledgement of their esteem for him. One admitted to me that he had a busy schedule lined up for the morning, and had been tempted to say 'no' to the interview, but had agreed to do it as a favour because he had a lot of respect for, and liked, his vet. We spoke of our mutual respect for him, and it helped to smooth the initial introductions. Not just my personality but also the personality of my veterinary gatekeeper was having an impact on who was willing to participate, and at what cost to their own time and priorities. Moser (2008) suggests that personality is the new positionality, and it certainly deserves further examination in geographical fieldwork.

In the November week of fieldwork I individually interviewed 22 people - ten farmers in Newtownards, seven private vets (4 Newtownards, 2 Mallusk, 1

Coleraine), four state vets (1 Ballymena, 1 Newtownards, 2 headquarters), and one research scientist. I also conducted my first focus group, which was with five state veterinary officers, each from a different division. The focus group lasted 80 minutes, and yielded valuable data from the experiences of veterinary officers at the frontline of disease control. The conversation was lively and there was lots of interaction between the group members. The farmer interviews were all set up through the same private vet as before, and again trust and esteem for him were evident. When I was obtaining consent for one of the interviews the farmer said that everything was fine because I had been 'sent out' by the vet, and he wouldn't have 'sent' anyone who was unacceptable. One of the state vets had previously questioned the value of the PhD, and he was a natural scientist sceptical of the value of social science research. I interviewed the research scientist to make preliminary inroads into exploring the potential of looking at the role of the bacterium which causes TB (*Mycobacterium bovis*) as part of my political ecology approach, involving the non-human as an actor in the network of disease. The interview proved valuable, and I decided to further pursue an exploration of the agency of the bacterium in the research. I saw it from an early stage as the forgotten actor in disease eradication.

Early January 2013 saw the fourth round of interviews, and this involved two farmers and three private vets. I had difficulty recruiting private vets, with staff shortages over the holiday period perhaps contributing to a failure to return calls and an inability to participate. The fifth and final fieldwork trip in May 2013 included the archival research and interviews with a UFU official, an MEP, three private vets, four DARD officials and a farmer focus group involving three farmers. It proved difficult to gather a focus group of farmers. Through a complex network of contacts starting with a veterinary friend I was put in touch with a gatekeeper who was both a farmer and a rural business employee and he contacted farmers and agreed to host the focus group on the business premises.

The focus group had been due to have at least six participants but particularly good weather on the afternoon meant that three did not come, with their own 'fieldwork' on the farm understandably taking priority. Because the farmers knew each other and had previously worked together in farming groups there was a very good chemistry within the group and discussion flowed freely throughout.

Overall, there was a strong gender imbalance in the interviewees – 76 men to 10 women. All of the farmers were male, which reflected the fact that the vast majority of farmers in NI are male (DARD, 2014a). The gender imbalance was particularly significant in the vets that I interviewed, where only 3 from 30 vets interviewed were female. There were a number of reasons for this veterinary gender imbalance. Firstly, most private practice principals in NI farm animal practice are male. Secondly, practice principals were more likely to volunteer to participate in the research rather than nominate more junior female (or indeed more junior male) vets within the practice. Thirdly, despite my best efforts through several channels to collect a group of private vets to participate in an all-female focus group, I could not persuade any female vets to participate. I reckoned that the best way to persuade vets to be interviewed was to turn up at the practice spontaneously – if they were there and happened to be free, this tactic worked well. An approach through the official veterinary representative bodies requesting volunteers for a focus group proved unsuccessful, and their recommendation was to approach vets individually. My prior successes with veterinary focus groups on diagnostic sampling had provided grounds for optimism, but a focus group of private vets proved impossible for TB. I found vets were generally more difficult to persuade to be interviewed. I suspect that some of this may have been due to the sensitivity of the topic, with disillusionment and tension in the relationship between vets and DARD about TB testing standards, as will be discussed in Chapter 8. Fieldwork is sometimes messy, and needs to adapt to, and accept, the circumstances arising in the process of the time-constrained endeavour that is a PhD: not all goes according to plan (Billo & Hiemstra, 2013).

'Placing' the interviews

It is useful to reflect on how the interviews may have been affected by where they were conducted. In all cases the interviewees in this research chose the specific site for the interview to take place. Sin (2003: 306), discussing the 'place' of an interview, argues that interviews are at least partly 'structured by the spatial context in which they are conducted,' and Saunders and Moles (2013: 26) suggest that 'place speaks'. Others argue that the 'placing' of interview encounters should be considered as part of the methodology of research (Elwood & Martin, 2000; Anderson & Jones, 2009; Riley, 2010).

Thirty of the farmer interviews were conducted in the farm kitchen (with the vast majority of these at the kitchen table); four in the farm office; three in the farmhouse sitting room; and the farmer focus group was held in a business premises. The state veterinary officials were interviewed in DARD offices and premises where participants were based or happened to be on that particular day, including divisional veterinary offices (2 interviews), departmental headquarters (5) and an agricultural college (2). The private vets were interviewed in their clinics (10), and two multiple-person interviews were conducted in cars whilst travelling to and from a vets' meeting. The car interviews were most difficult to subsequently transcribe because of background interference from the noise of the car engine, and the moving car is not to be recommended as an interview site! The remaining (non-vet, non-farmer) interviews were conducted in offices according to where the participant worked and one was in the lounge of the person's home.

The choice of the farm kitchen was significant. Bennett (2006), in her ethnographic exploration of power dynamics in a Dorset farmhouse, noted that most visitors to the farm were seated at the kitchen table, and this was the site of the majority of my interviews with farmers. The kitchen table is the centre of the farm house. As the place where farmers would meet sales representatives, farm inspectors, farm advisors and state vets, it is a place to do business and a place of power and authority for the farmer. As well as place of business, the kitchen is a central, perhaps *the* central part of the home, but as farmers were keen to point out to me, their view of home encompassed the land and farm yard, and all contained within. Rather than testing cattle in a crush or treating a sick animal in a cow shed, now I was seated in the inner sanctum of the farm - the farm kitchen. Perhaps this had symbolic resonance for the farmer. The voice recorder sat on the table between us, but for the most part it was soon forgotten by my interviewees, and they talked seemingly without hindrance. The farmers were being interviewed on their 'home turf', and in a position of power with which they were very comfortable. As I sat across the table, I used a relaxed posture and did not produce any paperwork or notebooks apart from the consent form which was signed before the interview commenced.

Conscious of my powerful positionality as both vet (and particularly a former *state* vet) and researcher, from the outset I deliberately attempted to flatten or equalize power relations. If as a vet and researcher I was in a powerful position before the interview began, I did my best to equalise the positions between us during the interview by demeanour, lack of formalism, making eye contact, listening carefully, and even through the use of local dialect. I could speak 'their language', and with the same accent as many of my interviewees, I was similar to them, further enabling the formation of rapport (Hopkins, 2007b). This seemed to work – even with those I had never met before I felt that there was very soon almost a common bond between interviewer and interviewee, and conversation was unrestrained and natural in the vast majority of cases.

The farm kitchen, in addition to its obvious role as a place to eat, may also have traditionally been viewed as the workspace for women as well as a place of farm business for the men of the house: it certainly was when I was growing up on the farm. Of the 31 farmer interviews conducted in the farm kitchen, the farmer's wife was present in just 9 of them. More farm wives are working away from the farm, perhaps in a bid to boost incomes in times when farm margins have been tighter than they were in the halcyon days of farming. Five farming wives contributed to the interviews with their husbands, but only one of them sat at the table along with the men from the time the 'on' button was pressed on the recorder. This lady specifically asked if she could be part of the interview, and persuaded her son to join in as well. Another edged ever closer to the table from her activities at the kitchen sink, initially contributing occasional comments from the margins of the room as she listened intently to the conversation, but eventually sitting at the table alongside her husband and sons to fully participate. A third woman again gravitated from the kitchen bench towards the table, and she actively contributed throughout the whole interview. Another remained at the bench preparing food, but it was obvious that she was actively listening, keen to hear and follow the conversation, with occasional comments chipped in at appropriate moments. Amusingly, the fifth farming wife arrived into the kitchen laden with groceries after a shopping trip, and came into the kitchen asking if 'All the work [was] done?' (Int A26). This was more than a curiosity, but rather a jibe attracting attention to her state of busyness while we men sat talking at the table. She stopped for a short time and asked about badgers and their role in TB and suggested that badger vaccination was the way to 'let everything live in peace'. As Riley (2010: 653) also found, 'the role of [the farmer's wife] was fleeting, but impacted on the interview', and the 'place [the kitchen] allowed the interview to "bring in" other respondents and narratives'. Having generated the data, the next task was to transcribe, analyse, and write about it.

Interview data analysis and write-up

All of the 62 interviews were fully transcribed using *f4* transcription software (audiotranskription.de), and coded using *NVivo* (Version 9; QSR International Ltd.). I did not start using *NVivo* to code the transcripts until I had conducted the first two batches of interviews and had transcribed multiple interviews. By that stage I had a good grasp of the themes coming from the interview data. Yeung (1997: 62) accuses some qualitative researchers of paying 'only lip service to the iterative interplay of data collection and analysis that is at the heart of grounded theory method', but I tried to avoid falling into the same trap. I initially created what I called first level themes and then subordinate themes to code in *NVivo* (see Table 2), but added to and refined the coding throughout the process of analysis.

I came to the subject with what Gummesson (1991:50) calls 'preunderstanding'. With my farming background and immersion in the subject of TB for many years, I formed categories more readily, even before going out into the field to generate data. The danger here was that I would miss the emergent categories, but I was especially sensitive to this risk, and my categorization and lines of questioning and comparison changed throughout the stages of the research process, both in the field and in coding and analysis. For example, I became much more aware of the pressure that many farmers faced through regulation during the course of the interviews, and also how much the mysterious heterogeneity of TB confused farmers in comparison to other animal diseases.

There was therefore a process of iterative engagement with the empirical findings, a process of studying the data, formulating conceptual categories and theories emerging from these concepts, before returning to the data to compare, modify and refine the conceptual and theoretical. This was aided in my case by the gaps between fieldwork trips, with transcription and preliminary coding of the data taking place between trips, in accord with Glaser and Strauss' (2008: 43) recommendation that 'all three operations be done together as much as possible' to 'blur and intertwine continually'. Not all of this was physically possible in the time between fieldwork trips, and the bulk of the analysis had to be done after fieldwork had been completed, but most of the transcription and at least some of the coding and analysis was being done between trips.

I analysed the data using themes and concepts in relation to my research questions, and using a 'grounded theory' approach (Knigge & Cope, 2006; Glaser & Strauss, 2008). Glaser and Strauss (2008: 1) state that their grounded theory is 'a general method of comparative analysis' to create the 'discovery of theory from data'. In doing so, they aim for theory that is derived from the data, which fits the data, and that 'works' to provide suitable explanations and interpretations of the data. All the while they emphasize this as a research *process*. They warn against the dual perils of 'forcing the data' to fit preconceived ideas and 'a neglect of relevant concepts and hypotheses that may emerge' (Glaser and Strauss, 2008: 34).

As I started to write each chapter of the thesis I subdivided the subordinate themes and made further detailed notes, pulling out quotes which I thought illustrated the arguments I was making as I wrote. I found this more manageable than using *NVivo* to burrow down to a finer resolution of analysis, but always mindful of the need to link back to and between higher level themes and content, conscious of the risk of decontextualizing the data at very fine resolution. I often went back to the full transcripts to get a better appreciation of the original context of quotations. The back-and-forth of analysis and writing became intermingled, and not clearly defined (Crang, 2003), a continual process of drafting and re-drafting. Despite coming to the subject with ideas about what themes would be important in the data, during the process of reading and re-reading the transcripts I also looked for what else might emerge unexpectedly from the data with an 'openness to the unanticipated' (Crang, 2001: 221).

Table 2: *NVivo* coding breakdown

	First-level codes	Subordinate codes	No. of interviews	No. of references
1	Farmers and farming	Commitment	36	77
		Knowledge transfer	34	67
		Lay expertise	25	42
		Pressures	28	44
		Regulation, inspections, subsidies	48	97
		Vaccination	29	39
		Miscellaneous	10	15
2	Badgers	Intrinsic worth	15	19
		Role in TB	55	100
		Culling	53	87
		Vaccination	31	39
		Miscellaneous	6	6
3	TB as a disease	*Mycobacterium bovis*	25	48
		Biosecurity	53	111
		Zoonotic risk	21	24
		Cattle vaccination	22	30
		Eradication and the future	51	141
		Miscellaneous	59	171
4	Testing for TB	Skin tuberculin test	47	70
		Testing as a procedure	54	120
		Lay testing	22	24
		Miscellaneous	5	7
5	Emotion	Emotion and TB	45	132
6	Vets	Expertise	12	21
		Vet views of farmers	15	23
		Farmer views of vets	27	38
7	Miscellaneous	Governance issues	21	78
		Ethnographic positionality	13	20
		Heterogeneity	12	21
		Uncertainty	12	20
		Spatiality	42	75
		Farm as home	28	43

Interestingly, Glaser and Strauss (2008: 40) suggest that this iterative process goes on beyond publication of the findings: 'The published word is not the final one, but only a pause in the never-ending process of generating theory'. Despite the ever-present desire to return to the field to gather even *more* data, there was indeed a time to stop; it was not possible, or necessary, to 'know everything' (Glaser & Strauss, 2008: 73), and my task was not to furiously collect data like a squirrel gathering nuts for winter (Whatmore, 2003). I did struggle with that temptation. Rather, fieldwork and the subsequent data analysis was a process of reconstructing world-views and 'build[ing] up a picture' (Crang, 2001: 216) of TB in NI. This would form the basis for a chain of explanation throughout the writing of the thesis.

Reflexivity on methods and positionality

Feminist scholarship has particularly emphasized the need for reflexivity in research (e.g. England, 1994; Rose, 1997). Pini (2004: 169) points out that reflexivity 'makes transparent the context in which knowledge is produced and thus opens it up to scrutiny and interrogation'. I began this chapter with an autoethnographic account of my path to this PhD, but this biography is also relevant to the research process. My background as a vet and farmer's son undoubtedly opened doors and facilitated the research process. The network of contacts available to me within the veterinary and farming communities meant that people whom I approached directly were more willing to be interviewed because they had met me before, or knew of me through family or mutual friends. Of the 62 interviews, 31 were with people I had met before, and 31 with those I had never met before. This even split was not by design, it just happened.

Throughout the fieldwork, and particularly for those I had never met before, gatekeepers were very important in facilitating access to interviewees. Campbell *et al.* (2006: 98) define gatekeepers as 'those who provide – directly or indirectly

– access to key resources needed to do research, be those resources logistical, human, institutional, or informational'. Emphasizing the consideration of gatekeepers in ethnographic research, Crowhurst and Kennedy-Macfoy (2013:457) 'situate gatekeeping as integral to the entire process of conducting research'. In my research, several of the gatekeepers themselves became interviewees, adding to the complexity of the relationship between us, and demonstrating that they can be more than just 'instrumental gates' providing an opening to others (Crowhurst, 2013).

The interviews verged between being semi-structured and unstructured, and this often relaxed and conversational style of interviewing meant that they were fluid and varied according to the interviewee and their interests and experiences. Sayer (1992: 245) supports such an approach, and states that 'with a less formal, less standardized and more interactive kind of interview, the researcher has a much better chance of learning from respondents what the different significances of circumstances are for them'. Listening carefully to what was being said and picking up on the participant's flow of thought and argument were the keys to a good interview.

Valentine (2005: 113) suggests that both researchers and informants 'perform our identities and read those of others' in the 'relational moment' of the interview. I found myself shifting between farmer and veterinary identities, emphasizing (even subconsciously) at times one or the other, depending on who I was speaking to. I had personally been farmer, private vet and state vet at various times and in various settings – a complex positionality all rolled into one person. I could both empathize with and critique what was being said as I performed my rurality (Woods, 2010). Overall, my positionality and prior knowledge of the subject matter meant that I had the 'capacity to catch the interviewee's meanings, to perceive the framework within which he is talking' and thereby to be able to listen with what Dexter (2006: 28) called 'the third ear'. I was not just hearing and recording words – I understood where they were coming from (most of the time) - and even the local dialect and 'farmer-speak' / 'vet-speak' in which they were spoken, and which I often reciprocated. Rather than being in a position where the interviewer 'does not have enough background, enough knowledge, and enough sensitized imagination to catch the subtleties and complexities of what the interviewee is saying' (Dexter, 2006: 28), I was in the position of knowing enough to allow, and at other times to direct, the interviews to flow in interesting and useful directions.

This was not merely a case of understanding and collecting data. Whatmore (2003: 90) argues that research is 'an intervention in the world' and the generation of data is a 'co-fabrication' between researcher and researched. I was aware that both farmers and vets were keen to work out the mystery of TB, keen to see progress being made, and offering hope that perhaps, in some sense, we could work this out together. The following interchange with a farmer illustrates the nature of the detective work that we were 'co-fabricating', but emphasizing the *mystery* of what we were fabricating because of the perceived unknowability of the disease we were seeking to unravel:

> Farmer: 'Is there anybody ... can you get to the bottom of it?'
>
> PR: 'Not yet [*laughs*]'
>
> Farmer: 'It will be interesting for you to go ahead and get to the bottom of it, because I would say somewhere you'll hear'//
>
> PR: 'I'll try and make some progress.'
>
> Farmer: //'Somewhere along the line you'll find something to knock you all wrong - that it couldn't be that.' (Int A34, beef farmer)

It is impossible to fully know what effect my positionality as a vet, and particularly as a former DARD vet, had on my research participants. If there was an effect, it was more likely to be with the farmers, as there may have been a perceived hierarchy of power, with me as the powerful state official towering over the farmer. As already discussed, it did not appear to dissuade farmers from participating in the interviews, and in my judgement it did not lessen the quality of the data generated. My status as a vet also meant that I had a position of authority and comparatively easy access to my interviewees, and the vet's voice and influence as a 'professional' and 'expert' with Aesculapian authority is a powerful one (Armstrong, 2011). I was also conscious of how I could have been perceived as a powerful academic researcher having flown into the country to collect data before returning to the sanctuaries of the university ivory towers in England. It called for continual reflexivity throughout the course of the research process, assessing power relationships and how what I brought to the research and who I was influenced the participants (Tolia-Kelly, 2007), and reflexivity extended right through the writing-up phase of the research journey (Bingham, 2003).

Conversely, it could be argued that the interviewees were actually in control of power relations in the interview. I was the one who had come to them asking for help in understanding TB. They had the right to participate or to refuse; I was in their hands. Neither farmers nor vets are 'weak' individuals; they knew their own minds, and were perfectly willing to criticise and to blame (sometimes forcefully) when they felt the need. What undoubtedly made a difference is that my position as interviewer was as *student*, one willing to listen and learn, rather than as former state official enforcing the law of the land, a positionality which I always stressed, particularly to farming interviewees. When interviewing elites I felt in the subordinate position, and I was not the one 'controlling access to knowledge, information and informants' (Valentine, 2005: 114), and sometimes aware that I was being 'put right' if my question or line of argument was perceived to be controversial. For example, one senior state official criticised me for using the word 'draconian' in relation to state regulation, implying that I was taking the side of farmers. As England (1994: 249) suggests, ‘even being sensitive to these power relations does not remove them’.

My previous work as a vet with DARD was specifically mentioned or implied in 7 of the 38 farmer interviews. A farmer and a farmer’s wife both criticised the failure to take action on badgers as ‘you’ (plural), thereby identifying me with DARD collectively. Similarly, one of the farmer focus group participants suggested that TB was tacitly welcomed by DARD and its veterinary employees and that appeared to include me: ‘Fair play to you, but it’s keeping you [DARD vets] in work’ (Int A58, dairy farmer). A dairy farmer (Int A23) suggested that he would like to see more trust in farmers from ‘my’ [DARD] staff, as we would know who could be trusted through our personal knowledge and experience of past behaviour. Condemning DARD vets for being difficult to contact, a dairy farmer (Int A32) asked me how many holidays I got when I was in DARD. Another pointed out that he was asking me a question but not as a ‘Department man’ (Int A7, beef farmer). Finally, a beef farmer, when asked for his views on regulation, apologised for being critical of the Department: ‘There’s far too much red tape – I hope you don’t mind me saying this – the Department is far too strict,’ and he also suggested that DARD rules were often broken, ‘as you well know’ (Int A14, beef farmer). Whilst not specifically connecting me with DARD, a few other farmers spoke of me as a vet, or as an expert on TB. I was twice asked if there was not a better way to TB test cattle (Int A3, A4), and one of these farmers also asked me about progress on cattle TB vaccination (Int A3). In the farmer focus group I was asked about the progress of disease in infected animals, and whether birds carried TB (Int A58). Another farmer, when discussing herd fertility, pointed out that I would know about this as a vet (Int A23).

Having explained my employment history, and being open about the fact that the research was sponsored by DARD, there was perhaps also a sense, particularly amongst farmers, that I was a path to DARD, and an opportunity for their voice to be heard in the 'corridors of power' in headquarters. I had pointed out in the consent form that a copy of the thesis was to be provided to DARD at the end of the process. Now, having previously worked as a state vet, I was perhaps deemed fair game to be on the receiving end of what they really thought about DARD or the failings of the veterinary profession in general. Similarly, private vets used the opportunity to air grievances about DARD, particularly in relation to the inspection regime for TB testing: I had become a gatekeeper to the state. On the other side, DARD officials may have been willing to participate to counter or prevent an 'unbalanced' view of TB from farmers or vets at ground-level.

Trust was an important issue in the research, but this had the potential to create an ethical dilemma. Pini (2004: 174) relates how one of her interviewees felt that she had been 'too truthful' in answering questions because she as a researcher 'at home' had created empathy with the participants by using her multiple positionalities to emphasize being 'like' those she was interviewing. For me, this was particularly apt when interviewing vets, including former colleagues and senior officials, and I was conscious that there was a danger that comments may have been made off-guard because it was like a chat between old friends. In other words, there was 'exploitative potential' (Finch, 1984) in interviewing peers or those with whom the rapport was strong and immediate. Trust was a very important element of the interviewer-interviewee relationship, but at times it felt like walking along something of a tightrope, but those being interviewed were perhaps performing a role (e.g. as state official or private vet) and keeping to a script just as much as I was; perhaps some cards were being kept close to the chest, no matter how much rapport was developed in the research encounter.

Trust worked both ways, for I was also putting my trust in my interviewees that they were giving me accurate and responsible views on TB from their experiences and worldview perspectives. I felt myself becoming more personally involved and empathising with those who had suffered. At one point I had to stop transcribing the focus group interview with vets as I was emotionally overcome when the vets spoke of severe stress and suicides amongst farmers that they knew. The emotions of the researched had an emotional effect on me as the researcher (Bennett, 2004), and emotion is certainly a 'research reality' (Jones & Ficklin, 2012: 109). On a more optimistic and brighter note, I vividly remember the look of delight in the eyes of one farm wife who described her emotions when a two-year herd restriction had been lifted after a prolonged TB breakdown on the farm. Mere words cannot do justice to the excitement and sheer relief displayed as she leaned forward across the kitchen table to answer my question on how she felt; I joined in her joy.

I was certainly putting myself in a position of 'being at risk' in a Stengerian sense, in the position of being changed and affected by the data generated and the process I went through to generate it (Whatmore, 2003: 97-98). Like the experiences in the field described by Jones and Ficklin (2012), I found myself unexpectedly empathising with some interviewees, particularly farmers, where previous relationships between us as state vet and farmer may have been less empathetic. I also felt the burden of responsibility of producing a political ecology of TB that was 'useful' (Blaikie, 2012) and that 'worked' (Blaikie, 2008). This will be explored in the conclusions of Chapter 9, but certainly entering and leaving the field I felt a weight of responsibility resting upon my shoulders. Overall, I sensed there was a genuine, and sometimes desperate, desire on all sides to move forward the debate on TB and to create a constructive platform of progress for the future if at all possible, but a lot of confusion and indeed bewilderment about how and when that could be achieved. Instead of finding answers, perhaps I should have emphasized more that my task was to 'make interpretations' and create some form of order from all that we were co-fabricating (Crang, 2003: 127). The conclusion overall I reached was that the interviewees *enjoyed* the experience of speaking to 'an understanding stranger', one whom they could teach and with whom they could share on a subject of mutual interest. There was something in it for them as well as me to savour and find satisfaction in (Dexter, 2006: 41).

Insider/Outsider and somewhere in-between

It could be argued that I conducted this ethnographic research as an 'insider' (Dwyer & Buckle, 2009). With fifteen years' experience in TB control as a vet in private practice and in the state veterinary service, and also a lifetime as a farmer's son, I had been immersed in the subject for all of my working life. I was also born, raised and had spent most of my working life in NI, living and working amongst many of those that I interviewed, and there are great benefits from being thoroughly involved in the subject under study (Lofland & Lofland, 1995: 17). I could see the benefits of 'coming close', and as an insider to the problem of TB, I could ask the questions that needed to be asked (old and new), and interpret the findings in a way not possible to an outsider. Dyck (2000: 49) thought that while researching 'at home' had its own issues and problems, there were also distinct advantages, and that 'too little attention has been paid to the role of biography in shaping our awareness of research possibilities'.

My knowledge of the field helped to shape the research questions and who and where to conduct the investigations. Breaking up the whole of the TB eradication programme into its most relevant constituent parts (known as the process of *abstraction* in critical realist methodology – Sayer, 1992) was informed by my prior knowledge of the subject. This is particularly relevant and useful in a situation where 'many things are going on at once' (Sayer, 1992: 3) and the obvious question is where to begin, and how to untangle a multi-dimensional mess.

I certainly saw my unique positionality overall as a strength – I could speak the dialects and speak and embody the 'languages' of farmers and vets, and drew on this to 'establish rapport and communicate' (Dowling, 2010:35). But inscribing into the research 'some absences and fallibilities' (Rose 1997: 319), and as already described, I was very mindful of the liabilities my powerful positionality brought to the table. I was also aware that the knowledges I produced were only partial and situated, and versions of the overall reality (Mohammad, 2001). I echo Rose's (1997:305) comment that I could not pretend to be 'an all-seeing and all-knowing researcher', for who I was and am affected my view of the world, and affected my representations of that world. Being an 'insider' therefore also brings costs. The issue of TB is a complex and controversial one, and there were conflicting and strongly held views to report. My research was sensitive in that it may have an impact on future state TB policy, and so the findings could have important implications on all sides of the debate.

In researching sensitive topics, Lee and Renzetti (1993:4) defined such issues as those which 'seem to be threatening in some way to those being studied', and which involve potential costs to those either the subject of research or to those conducting the research. Research findings from participants could be used against them as 'ammunition to those already in power' (Barnes, 1979: 22). I was also wary of potential ridicule from former veterinary colleagues for having crossed the boundary between natural science and social science. Hamilton (2007; 2012), an accountant working within a veterinary practice who turned to social science, found that the vets she interviewed were keen to emphasize this boundary, describing her ethnographic work as the 'ethereal arts'. In my research there was mild bemusement from some, and bewilderment from others, about how *geography* could possibly relate to what they considered a veterinary and scientific problem, but on the whole there was positive and interested engagement. I was also mindful of Bourdieu's (1988:5) salutary warning: 'It is well known that no groups love an "informer" … hostile groups will be likely to question the credentials of the special lucidity claimed by anyone who seeks to analyse his own group'.

Despite my insider credentials, as human geographer I was also an outsider. I was no longer a practising vet; I had moved to live in England; and critically, my status and professional esteem had been reduced from expert professional to student. My history as a DARD vet already made me a step removed from private vets – I had crossed to the 'other' side and away from private practice in 1999. Even as a farmer's son I was away from the farm, and was no longer fully a farmer. Neither had my father's farm ever experienced a TB breakdown, unlike many of my interviewees. I only knew TB as a vet, not as one caring for a herd of animals on a daily basis under herd restrictions and a burden of disease. To many I was also a stranger – they knew nothing of my background apart from what I and my gatekeeper told them. All knew that I had worked for DARD. In all of these multiple ways I was an outsider - I had to be taken on trust, and allowed a glimpse into the 'inside' of TB at farm level.

England (1994:250) suggested that 'reflexivity can make us more aware of asymmetrical or exploitative relationships, but it cannot remove them.' I acknowledged and rendered visible my positionality to all of my interviewees before we began the interview (Gilbert, 1994). However, I also 'shuttle[d] between insider and outsider roles' (Herbert, 2000:552), playing one aspect of my positionality in my favour more strongly than the other according to who I was interviewing, shifting roles, performing fluidity - the state vet, the private vet, the farmer's son, the PhD student - stepping in and out of my various persona; performing multiple identities (Woods, 2010). With such performances, I could view myself as the 'insider-outsider' (Dwyer & Buckle, 2009), combining the best of both approaches.

Alternatively, a better description of my positionality could be as a 'boundary dweller' (Butz, 2010), occupying somewhere between the poles of insider and outsider, 'less crossing or straddling boundaries than inhabiting them' (Butz, 2010:149). On this theme of middle ground, England (1994: 251) thought that fieldwork was conducted 'on the world between ourselves and the researched' and this 'betweenness' was 'shaped by the researcher's biography'. Focusing on the research participants rather than the researcher, Tooke (2000: 218) explained the notion of 'betweenness' as 'the multiple and shifting ways that the researched respond to the researcher'. The research participants influenced and shifted my positionality – I was truly entangled in the research in a messy middle (Rose, 1997). This thesis is not therefore a 'view from nowhere' (Davies & Burgess, 2004), but it is surely all the richer for in being an interpretation of TB from somewhere in-between.

The following six chapters present the empirical findings of this research journey, beginning in Chapter 3 with the history of the TB eradication programme in NI, based primarily on the archival research described earlier in this methodology chapter. The themes and debates revealed in the state policy documents of the 1970s are recurrent through to the present day, as will subsequently be shown in Chapters 4-8. History shows the pathway to the present, and how the present has been shaped by what has gone before.

Chapter 3: History of TB eradication in Northern Ireland

This chapter provides an historical overview of the TB eradication programme in NI which began in 1949 as a voluntary scheme, but from 1959 became compulsory for all cattle herd owners. Tracing TB back through time sets the ethnographic investigations of the present day in context, and provides signposts for what developed in subsequent decades. As described in Chapter 2, the findings are based primarily on state documents of the Department of Agriculture in the public archive. Although this arguably provides a one-sided perspective, it nonetheless uncovers the roots of the controversies which have continued through subsequent years. Illustrating key themes and concepts from political ecology and STS which are developed and expanded in more detail in later chapters, this history therefore informs both the present and the future. It shows that for many years there has been an acknowledgement of social, economic, political, technological and ecological factors and their potential to influence the prospects of TB eradication in NI.

Figure 2: Men and beasts - Ayrshires in the field (Source: CAFRE photo archive of 1960s)

Political ecology and historical narrative

History is important in political ecology. Blaikie and Brookfield (1987: 100) note the importance of moving 'backward in time to understand the antecedents of modern conditions'. Robbins (2012a) emphasizes the importance of an historical and temporal dimension to political ecology research, and his work on Rajasthani forests typifies such an approach, looking at the present in light of the past (Robbins, 1998; Robbins, 2000). Similarly, Peet and Watts (2004:15) praise research which provides 'historical depth,' and Davis (2009) supports 'looking back to move forward'. Davis sees the benefits in 'trying to trace whose history and whose science becomes dominant over time, why this happens, and who wins and loses' (Davis, 2009: 286). For example, historical environmental research on deforestation in Africa has been the theme of monographs from both Davis (2007) and Fairhead and Leach (1996), and these notable political ecology studies have shown that dominant discourses accepted from the colonial past were erroneous and needing to be reframed. Offen (2004:20-21) asks whether 'historical context' for political ecologists necessitates 'treating time as a scale that extends backward from the present to elicit a "chain of explanation"…?' Offen (2004) suggests that Blaikie and Brookfield's (1987: 68 & 100-101) approach certainly emphasizes the need to look at how contemporary decision-making may be influenced by the past.

In looking back, how far back must one go to provide explanations? To pursue an in-depth historical overview and a historical political ecology of TB is beyond the scope of this thesis (and indeed is a thesis in itself) but without at least an elementary understanding of the past, it may produce a 'gaze from nowhere' (Haraway, 1988) in the present. The following therefore provides a broad sweep of TB eradication policy, starting in the 1930s, but with a more detailed focus on the 1970s, arguably a key turning point in the programme when eradication seemed to be within sight only to slip from the grasp of the state. At the very least, an historical introduction may provide suggestion of 'credible problems' (Thompson & Warburton, 1985: 124) with which to concentrate efforts in the present and provide guidance for the future.

The Attested Herds Scheme in NI

In the 1930s there were approximately 1,200 human deaths per year from tuberculosis in NI, with an estimated 5-10% caused by the bovine form of the disease (Russell, 1985). Two thirds of the human cases with the non-respiratory form of tuberculosis (more likely to have been of the bovine type) were found in rural areas outside of Belfast. Kerr *et al.* (1949) reported an incidence of 33% amongst 600 dairy cows examined in NI between 1945 and 1948, and 7.5% of milk churn samples were found to contain tubercle bacilli, illustrating the risk from drinking unpasteurized milk. In the mid-1940s about 25% of cattle were estimated to be infected with TB in NI, with the incidence as high as 40% in the dairy cows slaughtered in Belfast Abattoir (Russell, 1985). The presence of TB in cattle was a threat to public health, and one which needed to be addressed.

Efforts had begun before World War II to tackle the disease. From 1st April 1935 farmers were required to report suspicion of TB in their cattle to the police, who in turn passed on the information to the Veterinary Inspector for the area. Private vets who suspected TB were also required to report suspicions. After clinical inspection by a Ministry vet, cattle found to be affected by TB were compulsorily slaughtered by the state under the Bovine Tuberculosis (NI) Order, 1935, and restrictions were placed on the milk of such animals. Russell (1985) reported that between 1948 and 1953 an average of 300 animals per year were slaughtered under this legislation. Clinically-affected animals were recognised as 'poor doers' that lost weight, became progressively thinner, and eventually died. Even before fatalities, farmers suffered economic losses through reduced milk production, fertility problems, and susceptibility to other infectious diseases. Progress was made in removing such animals, and in Reilly's opinion (1950) there had been a marked decline in the number of cases of human tuberculosis of bovine origin in NI by the 1940s for three main reasons: milk pasteurization; education of the public about the risks from drinking unpasteurised milk; and the detection of TB through the tuberculin testing of cattle.

A voluntary eradication scheme based on cattle testing and administered by the state began on 2nd May 1949. It was known as the 'Tuberculosis (Attested Herds) Scheme', and at that time the animal TB incidence was approximately 25% (NIAO, 1993: 14). By January 1951 the Ministry of Agriculture's Monthly Agricultural Report stated that 'herd owners [were] becoming increasingly aware of the benefits which [the scheme] offered', and 400 had signed up to the scheme (MANI, 1951: 270). It consisted of the voluntary tuberculin testing of all cattle in the farmer's herd with the compulsory slaughter of positive ('reactor') animals. The scheme began with great confidence in a successful outcome, and the Ministry at this early stage confidently declared that 'it is now apparent that tuberculosis in cattle is a disease which lends itself to practical control measures' (MANI, 1951: 270). Designed to establish herds officially certified free of TB, the scheme provided financial assistance to farmers to achieve that status through testing, and a bonus of 30 shillings per year for each animal in the herd thereafter for three years, provided the herd remained TB-free (MANI, 1951). The basic tenets of the 1949 TB eradication policy - tuberculin tests, removal of reactor animals, financial compensation, movement controls, and the cleansing and disinfection of infected premises - essentially remain unchanged to the present day.

By May 1959 the Ministry reported a 'flood of applications' to join the scheme, with 55% of the cattle population of NI involved (MANI, 1959a: 13). The farming community were reported to have responded with great enthusiasm, and in the opinion of the Ministry, 'their co-operation and goodwill has been of the greatest assistance in pursuing the campaign' (MANI, 1959a:14). The lack of vets (both Ministry and private) to conduct the ever-increasing number of tuberculin herd tests was regarded as the limiting factor on the on-going progress of the scheme (MANI, 1959a). This lack of testing manpower was a recurring theme echoed by state veterinary officials into the 1970s.

Compulsory eradication began in Counties Antrim and Londonderry from 1st September 1959, and the other four counties of NI were to follow down the eradication path on 1st January 1960 (MANI, 1959b). The Diseases of Animals Act (NI) (1958) provided the legislative authority to enforce the compulsory eradication of tuberculosis, and although all herd owners were therefore forced to comply by law, the Ministry was keen to praise the farmers for their co-operation: 'In the ten years of its life the scheme has gained the most surprising degree of support from the farming community, to whom all honour is due for their efforts' (MANI, 1960a: 273). This praise came with an exhortation: 'Herd owners and all others concerned are reminded once more that it is in the interests of NI that the eradication programme should be completed at the earliest possible date and that faithful observance of the rules is essential' (MANI, 1960a:273). Eradication was therefore explicitly connected to rule-keeping, and there appeared to be optimism about a successful conclusion to the programme. By the end of February 1960, 963,830 cattle (85% of the total population) were part of the eradication programme, and with the system of testing, valuation and removal reported to be 'working smoothly', the Ministry was optimistic that the target of all herds reaching attested status would be reached before the end of 1960 (MANI, 1960b). NI was indeed declared an 'Attested Area' on 25th November 1960 (Russell, 1985), meaning that TB had been reduced to very low levels.

The herd testing regime was changed from annual to biennial in 1965 based on the rapid progress being made towards eradication, and this was further reduced to triennial herd testing in 1971. According to Russell (1985:5), 'eradication proceeded smoothly from 1949 to 1971', and likewise Chalmers (1976) stated that TB eradication was 'initially a straightforward exercise and rapid progress was made'. In fact, so successful were the first two decades of the programme that TB was thought to have been 'virtually a thing of the past' (Russell 1985:5) by the early 1970s. But hopes of having conquered TB were raised only to be later dashed. Using the memoranda, minutes of meetings, and internal letters of state veterinary and animal health policy officials in the 1970s (PRONI AG/33/30, 1972-1977) one can trace the rising concern about a changing scenario in the 1970s when progress towards eradication became instead regress towards entrenchment. Recurring themes emerge from the archives which replicate many of the debates of the present. They are discussed in what follows in largely chronological order, unfolding a narrative of TB eradication gone wrong, with the state struggling to govern the messy realities of TB in the field.

Heading in the wrong direction – the early 1970s

In a memorandum dated 30th March 1972 (PRONI AG/33/30-a, 1972) the Chief Veterinary Officer Mr Edwin Conn (CVO from 1959 until 1983) sagaciously stated that 'from time to time we must take stock and see how work is progressing'. He had noted reports of an increase in TB reactors and TB-lesioned animals across NI, but thought that it had not yet reached 'worrying proportions.' He was however 'anxious to ensure that the seeds of a problem are not being sown.'

Progress towards eradication appeared to be in reverse for the first time. Rumours were circulating about the standard of testing by vets, and the CVO speculated that '[skin] measurements are not being taken at both visits', and emphasized that 'the necessity for such measurements to be carried out cannot be overstated'. He asked that both Veterinary Officers (VOs) and local private veterinary practitioners (PVPs) be reminded of the need to accurately conduct the tuberculin test, especially with a view to reducing the number of TB reactors before the impending UK entry into the European Community.

Three years later, while reflecting on the increasing incidence of TB in the previous years, state vet Mr Martin (PRONI AG/33/30-b, 1975) suggested in June 1975 that there were a number of reasons for the trend. Firstly, after the introduction of biennial testing in 1965, there had been an increase of TB to 1967, but this had subsequently decreased. On the same reasoning, he suggested there could have been an increased incidence after the introduction of triennial testing in 1971. Secondly, Martin mentioned that the national cattle herd was increasing in size, and that there was intensification in the husbandry required to manage this increase in numbers. Thirdly, some blame, he suggested, was to be attached to the interpretation of tuberculin tests by vets in Divisional Veterinary Offices (DVOs) which had been too liberal. Similarly, PVPs in the field had been classifying animals as inconclusive rather than positive to the test, allowing truly infected animals to remain longer on-farm than was necessary. Fourthly, cattle imported from the ROI were deemed to be important due to the higher incidence of disease in the South. Martin concluded that there needed to be monitoring of the standards of testing, and that biennial testing needed to be reconsidered rather than triennial if the 1975 incidence figures remained high. In other words, Martin recommended that the governance of TB, and specifically vets and cattle, needed to be improved.

A lack of veterinary manpower for testing was also noted in 1975, just as it had been in the late 1950s. Mr Ogg (PRONI AG/33/30–c, 1975) stated that TB testing was falling behind as a result, and that there was not the manpower available to change the testing regime from triennial back to biennial. A similar view was echoed by Mr Hutchinson in September 1975 (PRONI AG/33/30-d, 1975), with apparent shortages in both the Department of Agriculture and in private practice, and a concomitant backlog of overdue tests. Mr Christie (PRONI AG/33/30-e, 1975) suggested that the reasons for the upsurge in TB were the high volume of cattle imports from the ROI; the long intervals between tests; and spread from primary foci. He echoed calls to revert to biennial testing in response to the worsening situation.

Struggling to cope

Following the significant deterioration in the TB situation through these early years of the 1970s, Mr Chalmers (PRONI AG/33/30-f, 1975) wrote to an official in the Department of Finance on 12th December 1975 to ask for financial provision to be made to cover the cost of reverting from triennial to biennial testing to begin on 1st April 1976. Several reasons were given by Chalmers for the deteriorating situation, and to justify the change in testing regime, echoing earlier conclusions and calls for change. First, there had been difficulties in recruiting enough vets to fill the authorised complement for Department staff over the previous several years, and this difficulty was mirrored in private practice. As a result the testing programme had fallen behind, and by November 1974 there were 7,560 overdue herd tests. The combination of triennial testing and the backlog of overdue tests meant that some herds were not being tested for up to four years, allowing ample time for within-herd spread of infection. Second, given the substantial number of cattle imports into NI from the ROI, there was serious concern about the high levels of TB south of the border. Attempts since May 1973 to impose a pre-export test for imports from the ROI had thus far failed due to political opposition, but it was now going to be imposed. To worsen the situation, there had been no testing in the ROI in the six months previous due to a dispute between veterinary practitioners and the Irish state. Additionally, imported store cattle (young beef cattle bought for further fattening) were often slaughtered or moved before they could be tested, and along with the long test intervals, these factors concealed the true scale of the problem. Third, there were factors connected to cattle demographics. There had been a marked increase in cattle numbers in the early 1970s, with a 25% increase in total number of cattle and herd size between 1972 and 1975. There was also said to be a 'massive' movement of cattle between these herds. Changing the testing regime was to prove costly: reverting back to biennial testing was estimated to cost an additional £150,000 on top of the £180,000 already being spent per annum to pay PVPs for testing, but Chalmers concluded that there was no alternative:

'Failure to take such action would undermine the substantial government investment already made in the tuberculosis eradication programme. This would have very wide implications for the whole agricultural industry and in an EEC context could result in the necessity to pre-movement testing and biennial herd testing.'

A meeting was held on 10th March 1976 to further discuss TB policy (PRONI AG/33/30-g, 1976). The CVO expressed concern over the increase in TB incidence, especially in 1974, and he outlined the main reasons why he thought this had occurred. These repeated the earlier concerns, and also suggested poor quality testing by practitioners and inadequate attention being paid to test results by overworked DVO staff. He acknowledged that from 1972 the emphasis had been placed on brucellosis control, with TB no longer regarded as a problem. Farmers were also blamed for not presenting all of their stock for tests, and he suggested that there was 'a lower standard of morality due to the Troubles'. Movement of stock was seen to be a significant means of spread between herds, but the high stocking densities on grazing land was also mentioned, with no resting of pastures possible. Additional VOs had been drafted into the problematic Coleraine division with no improvement in TB levels, despite testing double the number of herds in 1975 compared to 1974. Mr Armstrong suggested that this experience had shown that 'increased frequency of testing on its own was not sufficient' and this had significance for the proposed reversion to biennial testing. The new tuberculin test, using bovine tuberculin rather than human, had been introduced the previous year on 1st March 1975, and the after adjustments the specificity of the test was now more appropriate in identifying truly infected animals. Department staffing issues were again to the fore, with lay staff being diverted onto brucellosis control rather than checking animal isolations and the cleansing and disinfection of infected premises, and there was a failure to conduct proper epidemiological investigations of breakdown herds. Department vets were to be 'exhorted ... to better and more detailed efforts' and more veterinary staff were to be recruited. Mr Ogg concluded that 'the Department had failed in its responsibility to provide an adequate Veterinary Service' in struggling to cope with TB and brucellosis simultaneously (PRONI AG/33/30-g, 1976).

In a later memorandum (PRONI AG/33/30-h, 1976), Mr Chalmers controversially suggested to the CVO that non-veterinary Department staff should be used to conduct lay TB testing to cope with the veterinary manpower shortage. This theme which was further discussed in subsequent meetings in the 1970s, and one to which attention returned 40 years later with DARD trials of lay TB testing strongly criticised by private vets (see Chapter 6).

Matters of concern

A meeting in May 1976 provided further updates on the situation (PRONI AG/33/30-i, 1976). The CVO noted the overall TB situation was 'potentially serious' and 'it was giving cause for concern'. Infection was springing up in new areas, particularly in Ballymena and North Down, and the situation in the Coleraine division continued to be especially troublesome. More testing by itself was deemed not to be the solution, and a system of permitting animals from affected areas and the possibility of pre-movement testing were discussed as additional policy changes. There were also increasing reports of testing 'not being carried out properly,' and the CVO said that some vets had been removed from testing, and 'every effort was made to detect misdemeanours'. Mr Ogg had travelled around NI and met with vets to 're-educate' them about TB testing. The issue of a vet testing their own client's herd was raised, and the CVO suggested there would be opposition to changing the status quo. The minutes record that: 'Veterinary Division representatives were unanimous in their opposition to the suggestion of employing lay staff on TB testing and were of the opinion that this would be most strongly opposed by the RCVS [Royal College of Veterinary Surgeons – the governing body for vets in UK] and could lead to serious trouble'. The CVO felt that there was no case for lay staff and believed that more veterinary staff was the solution, but presciently 'indicated that he would not go so far as to say that this would never come'. The intended future direction of the CVO was summed up in the closing minute: 'Veterinary Division was pinning its faith on more testing, more frequent testing, import controls, more policing by lay and professional staff, and a close study of herd breakdowns' (PRONI AG/33/30-i, 1976). More attention to governance was clearly seen to be the solution to TB eradication.

In response to this meeting, two weeks later Mr Chalmers wrote to the CVO (PRONI AG/33/30-j, 1976). Chalmers began by stating that he had an 'increasing concern that we may not be tackling TB as effectively as we could with our attainable resources'. He criticised the CVO's stance that the situation was '*potentially* serious [emphasis in original]', and in his view this 'would tend to under-state its immediacy'. Using statistics on disease incidence to support his argument he suggested that the disease had been 'increasing exponentially' since 1971. Although the initial cause for concern in 1972 had been the Coleraine divisional area, between 1974 and 1975 the incidence of the disease had trebled in the rest of the Province. The agreed measures from the policy review meeting had been extra policing and enforcement; 're-educating' PVPs; biennial testing rather than triennial; further import controls; and further epidemiological investigation of breakdown herds. But Chalmers launched a devastating critique of these measures. He pointed out that 're-educating' PVPs had failed to achieve better results in the past, and he saw no reason for it to work now. He did not hold out hope for biennial testing, as shorter-interval 10-monthly testing had failed to achieve results in Coleraine division. He suggested that eradication could be achieved through centralised control rather than the current arrangement of decentralized management through the divisional offices. He challenged the Veterinary Division's opposition to close supervision of PVPs, despite their view that 'a number of rotten apples' amongst vets had been responsible for the high levels of disease in certain areas, and was strongly in support of the introduction of lay testers to overcome the veterinary staff shortages for testing and the view that the 'control of private practitioners presents difficulties'. His conclusion was damning, and perhaps could be described as prophetic:

'I am bound to say that I feel our chances of getting a grip on the disease without taking measures substantially more radical than those we agreed at our meeting are not very great ... I have the feeling ... that we may have deployed a nut to obstruct the progress of a steamroller!'

Chalmers believed that the veterinary staff shortages would continue as vets were in short supply, and were unlikely to be attracted into the Department given restrictions on government expenditure. To gain perspective on this shortage of vets, Connolly (1968) reported that there were 130 vets in private large animal practice in 1966, compared to around 300 in 2013 (Robinson & Epperson, 2013), with an increase in the total cattle population of just 25% in the intervening period: the numbers of cattle to be tested per vet would indeed have been challenging. Chalmers concluded his memorandum by accepting the personal difficulty for the CVO in the matters that he had raised, but felt that in not raising them he would have been 'shirking [his] proper responsibilities.' Not all were therefore in agreement with the CVO's outlook on the way ahead, and there was dissension in the ranks.

Badgers enter the fray

The way forward on TB was proving troublesome. Governance of the disease had by the mid-1970s become a difficult and demanding challenge, and finding a scapegoat would probably have been welcomed by state officials. Badgers, so much the subject of controversy in epidemiological and political debates on TB in the present day, were first mentioned in the Department's documents in October 1976 (PRONI AG/33/30-k, 1976). The first badger to be discovered as TB-positive had been found in Gloucestershire in April 1971, and the role of badgers as possible carriers of TB was obviously on the minds of Department officials. Fifty badgers had been examined in NI, but just one was found to have generalized TB. The significant conclusion was drawn that badgers 'should not be regarded as a primary cause of herd breakdowns' (PRONI AG/33/30-k, 1976). In a further memorandum, dated April 1977 (PRONI AG/33/30-l, 1977), the results of more badger post-mortem examinations were reported: from 80 post-mortems just 3 were found to have lesions consistent with TB. Based on these samples, the disease certainly did not appear to be widespread in the badger population of NI in the 1970s. In contrast, by this point TB had now spread right across the cattle population of NI, rather than being confined to a few troublesome areas.

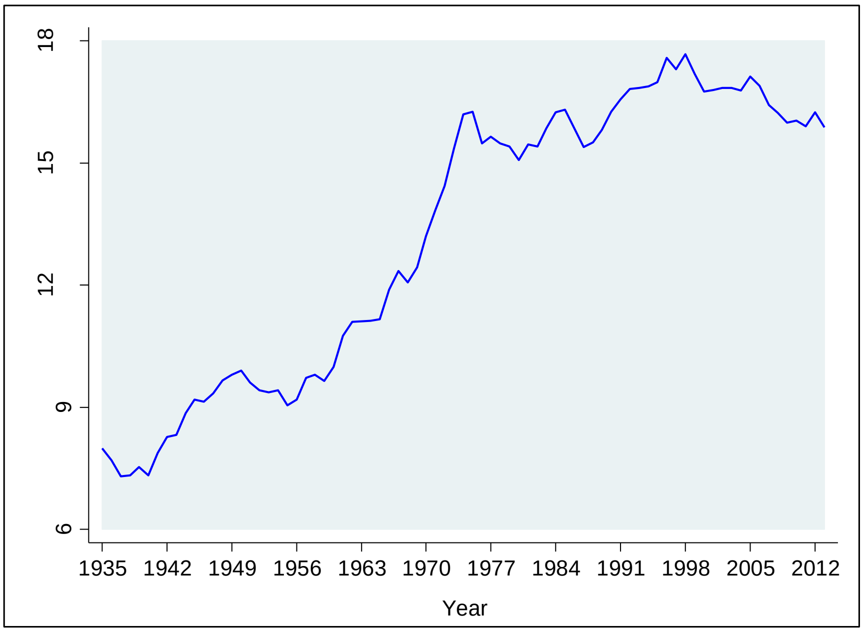
In a telling conclusion to the memorandum it was stated that 'a great deal more effort – right across the board – will be needed if TB is to be eradicated'. Towards the end of 1977 there remained issues about a lack of veterinary staff, and this was said to be preventing a move from biennial to annual testing (PRONI AG/33/30-m, 1977), but this change took place in July 1982 when the routine herd test interval was reduced from two years to one year in a return to the position of 1965.

Reviewing what went wrong – a view from 1985

Mr G.P. Russell, the senior state vet then in charge of the Department of Agriculture's TB programme, reviewed the history of the TB eradication programme in NI from 1949 until 1985 (Russell, 1985). The unpublished Department of Agriculture document, presumably written for the benefit of the Department's own Veterinary Officers, aimed to provide 'background information to enable false or misleading statements to be corrected and veterinary advice reinforced whenever tuberculosis [came] up as a topic of conversation' (Russell, 1985: 8). After summarising the nature of the disease and its transmission in cattle, reasons for eradication efforts, and the specific control measures employed in NI, Russell went on to discuss the problem of achieving the goal of eradication. His reasoning expanded and developed the debates of the 1970s policy meetings in Departmental headquarters. He suggested three main reasons why he thought that the disease became re-established after the early 1970s, a point in time when the disease had been so close to being eradicated.

Firstly, he noted the significant increase in the national herd, which had increased markedly between the 1950s and mid-1970s (Fig. 3). Sullivan (1979a) noted that the number of in-calf heifers and suckler cows in NI increased by nearly 50% between 1968 and 1973. Edwards (1991) suggested that beef cow numbers had reached a high point by 1974 with the expectation from farmers that EC entry would boost trade, before subsequently decreasing for a period of years. In the dairy sector, average herd sizes increased from 19 cows to 39 cows between 1974 and 1986, with dairying regarded as an increasingly attractive commercial proposition (Edwards, 1991). These increased cow numbers resulted in more animal movement, a higher stocking density, and more potentially infected manure requiring disposal on land. Russell stated that the uniquely high stocking density in NI was reckoned to be twice that of GB and four times that of Scotland. The volume of cattle movements was regarded to be very high level compared to other countries, but similar to the ROI. Russell quoted a visiting veterinary TB expert as having suggested that ‘farmers in Ireland appear to regard [cattle markets] as local versions of the casino at Monte Carlo’ (Russell 1985:6).

Figure 3: Total cattle population of NI: 1935-2013 (Source of data: DARD)



Secondly, and connected to the first point, in Russell’s assessment the importation of breeding females from the ROI was thought to be another major factor in the increased disease incidence between 1971 and 1975-76. Demand for cattle was high north of the border, and in addition to legal movements, illegal movements, including cross-border smuggling, were occurring. Illegal importations of females between 1971 and 1975-76 were thought to have been responsible for concurrent TB and brucellosis increases. Similarly, around 1980 the illegal importation of beef steers and heifers from the ROI were held to be responsible for the increase in TB and the slow progress in the following years. A decline in beef cow numbers in NI between 1974 and 1980 had caused a reduced supply of home-reared stock and increased demand for imports in 1980 to fulfil the demand for beef fattening (Edwards, 1991).

Thirdly, the 'conacre' system (Irish system of land tenure with land rented between April and November) involved farmers renting land often at some distance from their main holding. This meant that infected herds were potentially distributed over wider areas, with multiple neighbouring herds being potentially exposed. Changes to animal husbandry, with increased stocking densities at both housing and at pasture, also provided increased chances of close contact between infected and non-infected cattle within herds as well as between herds.

Additionally, but less significantly, in Russell's opinion farmers were also to be blamed for a failure to present all animals for TB tests, both deliberately and accidently. Badgers came into the equation too, acting as reservoirs of TB infection. Russell also thought there was a very social and human dimension – a lack of motivation, or a loss of will: 'Complacency on the part of all those involved in the eradication programme, because tuberculosis in cattle was thought to be a thing of the past' (Russell 1985:6).

Russell (1985:7) assessed the 'cost of failure'. Despite the success of other developed countries in eradicating TB, NI still had a significant problem in 1985. Unless rapid progress was made, he suggested that 'very searching questions' would be raised about whether publicly-funded expenditure was providing value-for-money in terms of animal and human health benefits. His estimated total cost for the TB eradication programme from its inception until March 1984 was £39.5M. If public funds were withdrawn, he believed that the programme would have reverted to a voluntary scheme, with loss of international reputation for NI as a 'leader in animal health matters', and future difficulties for the export of live cattle and cattle products. He suggested additional control measures, particularly the computerisation of animal health records to increase efficiency and control movements, and the development of a serological (blood) test to replace the tuberculin test.

Despite all of the existing, and additional, control measures which Russell outlined, he believed that the 'active co-operation of all herd owners' was essential for them to function effectively (Russell 1985:8). He concluded that 'in a very real sense, the key to successful disease eradication lies with the herd owner and he must therefore be given sound advice and encouragement whenever possible' (Russell 1985:8). Deputy Chief Veterinary Officer Mr Bill Sullivan (1979b:17) had taken a similar line writing six years earlier:

'There are many things a stock owner can do to prevent and control the spread of tuberculosis. Farmers should not only endeavour to do these things but should encourage their neighbours to do so as well. Combined action between the farming industry and the Department of Agriculture will reduce tuberculosis to an even lower level than that at present'.

Fuelling eradication - economic incentives

If farmers were thought to be the key to TB eradication, what incentives encouraged their co-operation in the programme? In this regard, the historical importance of economic drivers for the eradication of TB cannot be ignored. Whether as compensation for reactors; bonus payments for disease-free herds; or improved market conditions through export markets, economic factors have always been at the forefront of farmers' minds, and not just in NI. As Magnusson (1941: 206) noted in Sweden more than 70 years ago:

'The retrogression, stagnation or progression of the anti-tuberculosis campaign has always in the long run depended on economical (*sic*) factors. If the animal-owner receives compensation for his losses he is always prepared to co-operate to the fullest extent. That Sweden seems in recent years to be able to solve the tuberculosis problem so successfully … is undoubtedly due to ample state grants … in furthering tuberculosis work.'

Russell (1985) suggested that the main justifications for initiating a TB eradication programme in NI were the zoonotic effects of cattle disease on human health, and the negative effects TB had on the efficiency of cattle production. These were undoubtedly important factors, but the increased value of disease-free animals for the export trade could certainly be added to the list.

There was a substantial and longstanding tradition of exporting live cattle from Ireland to Great Britain (GB), and this was greatly facilitated by the introduction of the railways and steamships for speedier and more economically-viable transport (Armstrong, 1989). For example, 16 million cattle were exported between 1878 and 1900 at an average of 700, 000 head per year (Armstrong, 1989: 183-184). Jones (2001) notes the impact of the cattle trade from Ireland (both north and south) to GB on TB eradication efforts. The need to protect this trade and prevent the closure of a key export market was a key driver for legislative change in both parts of Ireland to mirror developments on disease control in GB. For example, the Bovine Tuberculosis Order (NI) of 1926 and Milk and Dairies Act (NI) of 1934 followed the same legislative adoptions in GB in 1925 and 1934 respectively. The legislation in Britain therefore 'pulled up agricultural and sanitary practice in the Free State [ROI]' (Jones, 2001: 142), and the same could be said for north of the border.

Having had a voluntary TB Attested Herds Scheme since 1950, by 1959 95% of cattle in GB were in attested herds (Jones, 2001: 224). This put considerable pressure on both the Northern and Southern Irish veterinary authorities and the cattle industry to act as it raised the prospect of GB prohibiting the import of cattle from Ireland. On 31st October 1958 Mr John N. Ritchie, CVO for Great Britain, gave the George Scott Robertson Memorial Lecture at Queen's University, Belfast and spoke to the title 'Britain's achievement in the eradication of bovine tuberculosis'. In this lecture he spoke of the demand for store cattle in GB, but hinting that isolation and re-testing after import would no longer be acceptable, he warned his Northern Irish audience that: 'It is necessary to make sufficient advancement in eradication to ensure that these store cattle have reached a standard of freedom from infection which will justify their unconditional entry into herds in Great Britain' (Ritchie, 1959:3). As Watchorn (1965: 7) put it: 'The day was therefore coming when all Irish store cattle exported to Britain would have to be of attested status'.

As already described, TB eradication in NI had been voluntary since 1949, and two years later there was still a very low uptake, with only 1.8% of cattle having joined the scheme. That was to change over the next decade, because as Jones (2001: 224) points out, 'the decision in Britain in 1950 to extend the Attested Herds Scheme concentrated minds. By 1959 the percentage of the cattle population in attested herds in Northern Ireland had risen to 54.5%'. From the beginning of 1960 no untested bovines were permitted to enter NI from the ROI (MANI, 1960a), and in March 1960 the remaining areas in GB were brought under compulsory TB eradication, resulting in imports of untested cattle from the ROI being banned. The export trade of store cattle from the ROI 'hit bottom' (Watchorn, 1965:15). It can easily be imagined that a similar affect occurred in the north. Now the economic incentive to strive for TB-freedom was a very powerful one.

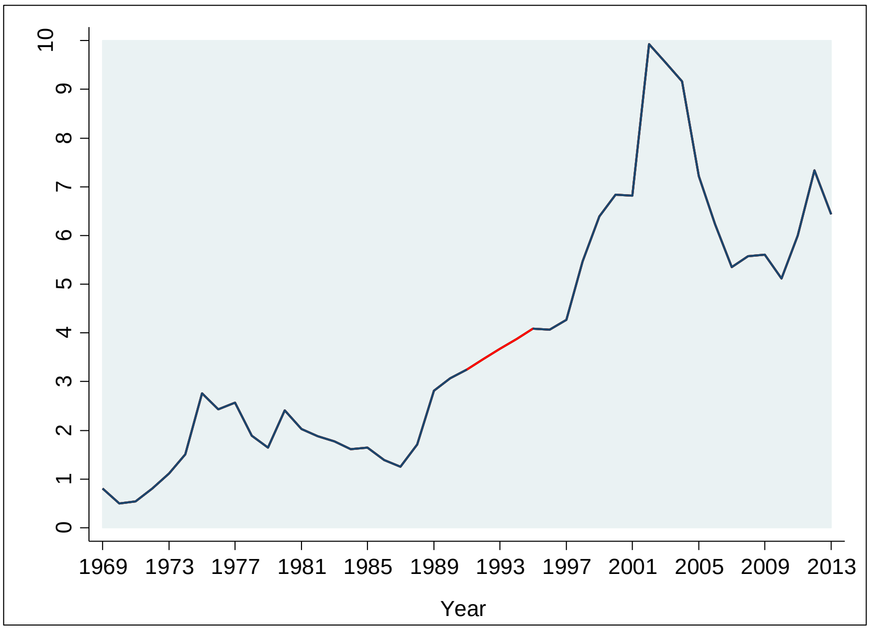
Moving forward to the present day, the absolute requirement to export NI-produced milk and beef still exerts strong market pressure on TB eradication efforts. Addressing the NI Assembly's Agriculture Committee at Stormont on 3rd

July 2012, Minister of Agriculture and Rural Development Mrs Michelle O'Neill emphasized the need for EU approval of the TB eradication programme, and stated that this was 'vital to safeguard [the] annual £1 billion-plus export-dependent trade in livestock and livestock products,' and that protecting NI's export status was 'a fundamental priority' for her Department (NI Assembly, 2012b:2).

A deteriorating picture - post-1985 to the present

As mentioned in an earlier section, annual testing was re-introduced in 1982 in response to the deteriorating situation of the previous years. This appeared to have some effect, for herd incidence reduced to 1.25% in 1987, the lowest it had been since 1973-74, but from 1988 onwards the levels of TB rose sharply once again (Fig. 4), prompting a Departmental review of TB policy in 1990.

Figure 4: TB herd incidence in NI: 1969-2013 (Source of data: DARD and NIAO, 1993)



*Herd incidence data interpolated for 1992-1994 due to missing values

The policy review panel concluded that the main causes of the rise in the late 1980s, and echoing the earlier concerns of the previous two decades, were as follows (NIAO, 1993:16): ‘excessive’ movement of animals; imports from the ROI (both legal and illegal); ‘leakage of infection’ from the ROI; inadequate fencing allowing contact between herds; ‘a lack of knowledge on the part of farmers about the disease’; and ‘the tendency of some farmers to delay or even actively obstruct the testing of animals’. The 1990 review also indicated that ‘the poor performance of a minority of private veterinary practitioners in carrying out tests may have contributed to infected animals not being identified’ (NIAO, 1993: 16).

The Department introduced an ‘enhanced eradication programme’ in January 1992, with the aim of reducing animal incidence to 0.06% by 1995, but it was noted that this depended on co-operation from the ROI in substantially reducing their disease level (NIAO, 1993). The actual animal incidence level in 1995 was 0.22%; the target had been missed, and disease incidence continued to rise seemingly inexorably thereafter. After the major Foot and Mouth (FMD) disease outbreak in 2001, when all TB testing had been suspended and all resources diverted to dealing with FMD for a period of several months, herd incidence reached a peak of 9.93% in 2002, before reducing and then rising again to reach 6.44% in 2013 (Fig. 4). The equivalent figure in the ROI at the end of 2013 was 3.88% (Department of Agriculture, Food and the Marine, 2014), and despite problems with TB eradication in the South in the 1970s, the ROI had moved closer to eradication than NI.

Bearing in mind that the herd incidence level had been reduced in NI to 0.50% by 1970, these figures did not make comfortable reading for those charged with eradicating TB. On 13th September 2013 Minister O’Neill, addressing the Committee for Agriculture and Rural Development, cautioned that: ‘Stakeholders will have to be realistic and accept that, as everybody in this Committee knows, there is no quick fix to TB and that it is likely to take a substantial time to achieve eradication here’ (NI Assembly, 2013a). The optimism of 1951 appeared to have evaporated, and TB was no longer described as 'a disease which [straightforwardly] lends itself to practical control measures' (MANI, 1951: 270).

Points of entry

This historical analysis provides evidence of 'points of entry' or 'credible problems' (Thompson & Warburton, 1985) with which to begin to describe and explain the contemporary investigation of TB eradication progress and policy, and helps to inform the research questions set out in Chapter 2. Firstly, the historical background of the TB programme demonstrates how disease, humans and cattle were brought into relation, and came to be known, through scientific practice and quantification, particularly through the technologies of TB testing (see especially Chapters 6 and 8). The failings of the tuberculin test and its conduct by private vets were often criticised by state officials in the 1970s, suggesting that this may be an important factor in the failure to eradicate. Secondly, history illustrates how the state came to intervene in an animal/human disease problem initially through voluntary, but later compulsory regulation, with a state emphasis on rule-keeping for both farmers and vets. Despite rapid initial success with this approach in the first 10-15 years, the state then experienced a growing failure to govern the disease and its actors, with most blame being attached to the humans involved (farmers and vets), a thread running throughout the subsequent chapters of this thesis. Thirdly, the importance of socio-economic and socio-cultural farming and land management practices involving cattle trading and land tenure come to the fore. These important themes are developed in the exploration of everyday life in farming in the 21st century (Chapter 4) and in the study of the ecologies of the disease within the landscape (Chapter 7). Fourthly, TB eradication has always been set within a political economic context, particularly in relation to the export of cattle and cattle products, and within the political and regulatory landscape of the EU. Even though export markets may once have been powerful driver for change, perhaps the political and economic conditions of modern farming have changed whereby farmers are no longer conscious of economic ‘sticks’ or ‘carrots’ from markets to eradicate the disease, and other tools of governance are used by the state to encourage (or force) compliance (developed further in Chapters 8 and 9). Fifthly, there has always been a sense of mystery and confusion on what the disease really is, and particularly how its lively and unpredictable behaviours can be anticipated and controlled; a subject looked at in more depth in Chapter 5.

Many years ago Kerr *et al.* (1946:443) warned against over-confidence when turning the investigative gaze ‘to tuberculosis, the literature of which is so vast, complex and, in some instances, contradictory, that ... it is no easy task to acquire a sufficiently complete appreciation of the results and fallacies of the information available’. It is not enough to rely on history, or to rely on the findings of others. Having moved back in time, it is time to leave behind the archives and to return to TB in the present. In Chapter 4 we begin the investigation by studying Northern Irish farmers and farming to explore how TB fits into the political economic and regulatory landscape of the modern cattle farm in the 21st century.

Chapter 4: Farmers and farming: economy and culture

Having considered the evolution of the TB eradication programme in NI in the previous chapter, Chapter 4 explores the rationales and sensibilities of cattle farmers and the agricultural political economy and regulatory framework within which they operate. This is important for understanding the farming context within which TB is located, and this context is a feature of the disease landscape which has been largely overlooked in the TB literature to date. Examining the premise that farmers are part of the problem of TB, and a link in the chain of explanation, this chapter will trace what it means to be a cattle farmer, and what everyday life is like for a farmer who lives with multiple uncertainties and indeterminacies in their farming present and future.

It will demonstrate that farmers are embedded within wider structures, particularly global markets and EU regulatory regimes, which condition and shape their actions. TB is but one important influence on their farming lives – there are multiple others. What also becomes clear through this chapter is that although farmers strive to run profitable businesses, farming is also a 'more-than-economic' activity. Farming culture has a very significant influence on why most cattle farmers have a passion for what they do, despite the daily workload pressures and economic uncertainties. The chapter begins by showing how farming and farmers are grounded in the literatures of political ecology, and reviews some of the ways in which farmers feature in the wider literatures of human geography. The chapter will then explain everyday life on the farm through the words of the farmers themselves.

Farmers in political ecology

Farming lives are important in political ecology. In Blaikie and Brookfield's 'classical' versions of political ecology (Blaikie, 1985; Blaikie & Brookfield, 1987), farmers (known as ‘land managers’) and their practices are central in their accounts of environmental degradation. For example, Blaikie (1985: 5) suggested a new approach to the problem of soil erosion involving a ‘place-based’ analysis of the problem, and particularly an examination of the ‘relations of production under which the land is used, the technology used and why, process, taxes and so on’. This provided what he called a ‘bottom-up’ approach where attention focused firstly on the smallest unit of decision-making for use of the land – the family farm – and then followed this up at different scales by looking at the village, and then the state. In doing so, Blaikie believed that this type of analysis looked at ‘where power lies and how it is used’ (Blaikie, 1985: 6).

Although Blaikie’s work was consistently focused on developing world contexts, there are parallels with farming in NI. Most farms in the Province are family businesses with an emphasis on livestock production. Whilst full-time family farmers and their farms act as independent economic units aiming to maximise economic efficiency, they are also culturally-embedded and more-than-economic. Farmers ‘know nature’ through being brought up working with livestock and intimately knowing both the cattle and the land on which they graze. Their expertise in the field is passed from one generation to the next, with a lifelong culture of informal, embodied and experimental learning practised and performed by many. In that regard they will not differ much from the ‘land managers’ whose performances political ecologists have studied over the years (Batterbury, 1996; Ramisch, 2011). But there also exists within NI a culture of formalised agricultural education for many younger farmers, more evident than in other parts of the UK. This is driven by a motivation for continual betterment and improvement allied to a strong work ethic.

While the multi-million pound Northern Irish dairy and beef industries may seem far removed from the peasant farmers of the Global South, the gap may not therefore be as wide as one might first imagine. Indeed, my research reveals interesting parallels. With constant uncertainties of climate and markets, a treadmill of work and regulation, and a loss of autonomy, European farmers are caught up in what van der Ploeg (2010:1) calls the global 're-emergence of the peasantry' or a 'repeasantization' (van der Ploeg, 2008: 7), which he claims is happening just as much in the developed countries of Europe as in the developing countries of the rest of the world. In this way farmers become 'citizens of Empire' (van der Ploeg, 2008). Under control and regulation by a powerful conglomerate of wider interests, and enrolled in 'the struggle for autonomy and space (which together constitute the core of the peasant condition)', van der Ploeg predicts this will become a global phenomenon in agriculture. Van der Ploeg (2008: 274) also argues that the peasant principle 'stresses the value and satisfaction of working with living nature, of being relatively independent, of craftsmanship and pride in what one has constructed. It also centres on confidence in one's own strengths and insights'. All of these qualities will be demonstrated in this chapter through the words of the farmer interviewees.

Galt (2013a: 639) thinks that capitalist agriculture remains 'a fairly minor topic in First World political ecology literature, especially vis-à-vis third world political ecology', and notes this absence as 'curious'. Viewing livestock agriculture in NI through the interpretive lens of First World political ecology will begin to redress this imbalance, and is very important in the context of TB.

Geographies of farmers and farming

Widening the lens to view the place of farmers in human geography literatures shows that agricultural themes have certainly not been ignored by geographers, featuring in rural, economic and cultural geographies with varying emphases over the years. Having moved away from behavioural (e.g. Gasson, 1973; Ilbery, 1978), and then predominantly political economy approaches to farmers and farming (e.g. Marsden, 1988; Pile, 1990; Whatmore, 1993; Marsden *et al.*, 1996), there has subsequently been more engagement with the wider 'cultural turn' in rural geography (Cloke, 1997). This has incorporated more qualitative and ethnographic research methodologies to produce 'agri-cultural' geographies (Morris & Evans, 1999; Morris & Evans, 2004). Riley's work on legacy and retirement amongst farmers (Riley, 2009a; Riley, 2011a; Riley, 2012) and gender relations (Riley, 2009b), are typical of this genre of cultural geography on a rural theme. Similarly, exploring the connections between place and farming cultures, Gray (1999), Mansfield (2012) and Cheshire *et al.* (2013) have all studied farmer identities and their connections to the land and place, and Riley and Harvey (2007) combine farming perspectives on landscape with knowledges 'from the ground.'

This emphasis on lay knowledges, and lay versus expert knowledges (Tsouvalis *et al.*, 2000; Proctor *et al.*, 2012), perhaps follows on from Wynne's highly-cited STS work on sheep farmers challenging expert advice in the aftermath of the Chernobyl radiation incident (Wynne, 1996). On a similar trajectory, there has been a return to studying farmer behaviour and decision-making, but blending this with knowledge acquisition and transfer, especially in relation to agri-environmental schemes and transition on farms (e.g. Morris, 2006a; Ingram, 2008; Riley, 2008; Riley, 2011b; Sutherland *et al.*, 2012; Sutherland *et al.*, 2013).

Given the all-pervasiveness of the non-human in terms of the objects and materialities which are acted upon and produced in agriculture, it is no surprise that increasing attention has been given to farm *animals* (Yarwood & Evans, 2000). With publications on animal breeding (Yarwood & Evans, 2006; Holloway *et al.*, 2009; Morris & Holloway, 2009); showing cattle (Holloway, 2004); engagement with technology (Holloway, 2007; Holloway *et al.*, 2014); and the place of livestock in the landscape (Jones, 2013; Sellick & Yarwood, 2013), these studies have further expanded the literatures of geography with an agricultural theme.

Despite this significant body of research within human geography connected to agriculture, the geographies of the practices and political economy of livestock farming at farm level have become less prominent in the literatures of the last decade. These literatures have become rather more focused on agri-food systems, food localisation and food security and governance (e.g. Stringer & Le Heron, 2008; Ilbery, 2012; Devaney, 2013; Marsden, 2013). Indeed, individual farmers and their farming practices have often been a constituent part of wider stories, and sometimes incidental to the overall argument. There is room to bring farmers and their livestock farming economies, farming from the 'bottom-up', back into focus, perhaps resurrecting a specifically *agricultural* geography long ago declared 'dead' (Atkins, 1988). Integrating it with a political ecology of capitalist livestock farming in the First World – an industry which is very much alive, particularly on the island of Ireland – refocuses on the politics and economy of farming in the everyday.

Refocusing on farmers

Farmers must be foregrounded in any analysis of TB eradication efforts. They own the cattle which succumb to the infection; present them for testing; buy and sell them; and determine their welfare and husbandry. Farmers are also the actors who interact with vets and state officials, and who comply with (or resist) the legislative basis for disease control. If we are therefore to understand the TB eradication programme, we need to understand more of farmers and farming in NI. Indeed, an understanding of the political economy of cattle farming in the early 21st century is required. Such an approach fits within our overall framework: there is a need for political ecologists to 'analyse the historical and socio-economic (or structural) context in which the local problem is situated, and … to trace the links of causation to factors in the wider political economy' (Thrupp, 1993: 51).

Whilst there are undoubtedly ecological and technical reasons for the persistence of TB, socio-economic and socio-cultural factors concerning farmers and the economies of cattle farming and its regulation by the institutions of the state are potentially an important part of the chain of explanation. Even within veterinary epidemiology, an essentially quantitative sub-discipline, the value of *qualitative* research investigating attitudes and behaviours of farmers is increasingly recognised. For example, studies examining mastitis control in dairy farming (Jansen *et al.*, 2009), zoonotic disease control (Ellis-Iversen *et al.*, 2010), and attitudes to biosecurity in Johnes disease control (Benjamin *et al.*, 2010) all found that the attitudes and behaviours of the farmers, including their knowledge of disease, had an effect on the intended outcome.

The same premise applies to TB. Enticott has conducted the majority of the geographical work on TB control with farmers and vets in England and Wales. With the state framing the issue of TB as purely a scientific and veterinary problem, he argues that the social and cultural aspects have been largely disregarded, to the detriment of disease control (Enticott, 2008a). Enticott particularly focuses on biosecurity, the attempt to separate disease agents from animals in time and space (Enticott, 2008a, 2008b; Enticott & Franklin, 2009; Enticott & Vanclay, 2011). Connecting biosecurity and animal health policy, he describes how this has become a key component of the state's strategy to regulate the flow of disease between and within agricultural enterprises, but finds that farmers have resisted such policies, dismissing them as unworkable (Enticott, 2008b). Farmers therefore legitimize illegal badger culling as they seek to protect their herds from TB, and emphasize the alienation which they feel from both scientists and the state (Enticott, 2011). Likewise, Fisher (2013) describes how trust and confidence in the state in relation to TB control is low, with farmers being unlikely to act on state advice on how to protect their herds from the disease. Farmers therefore feel helpless and powerless in the face of TB. Vanclay and Enticott (2011) use script theory to discuss the routines, catch-phrases, narratives and lines of argument when farmers speak of the disease. Developing this further, they also demonstrate that farmers value their own lay knowledge of TB, and have a fatalistic view on disease striking their herd, in spite of government advice on biosecurity (Enticott & Vanclay, 2011).

Here I build upon these literatures to explore why farmers may trust their own judgement rather than relying on the state for advice and why TB biosecurity is just one aspect of farming life demanding attention – there are multiple others. The theme of alienation from the state will be obvious not just in this chapter, but also becomes clearer as the thesis unfolds.

Blaming farmers for TB spread

The historical overview of TB in NI (Chapter 3) has shown that praise was showered upon farmers by state authorities when progress was made towards eradication in the early years of the scheme, but this changed to apportioning blame in the 1970s. In more recent years an influential audit report (NIAO, 2009) described how a minority of farmers in NI had not complied with legislative requirements on TB testing, or had been involved in fraudulent activity such as deliberately interfering with the skin test sites on animals to reduce or create skin swellings. The report called for more enforcement activity by the state to curb errant farmer behaviours which have been hindering progress towards eradication.

So are farmers to blame for the on-going spread of TB? Looking at success stories in the eradication of TB, Australia's eradication of the disease by 1991 was reckoned to be due to the full co-operation and support of the farming industry (Lehane, 1996; Radunz, 2006), implying that a failure to do so would have led to a very different outcome. Connections between farmer attitudes, behaviour and ongoing disease spread have been suggested in other countries where TB eradication has proved problematic. In the United States, farmer resistance was a feature of the early eradication programme, and incentives were required to ensure co-operation, leading to disease-free accreditation by 1941 (Olmstead & Rhode, 2004). O'Connor (1986: 52-53) believed that a failure to eradicate the disease in the ROI had led to 'almost a resigned acceptedness [*sic*] by some herd owners,' and a lack of further commitment from both farmers and vets. He reported that vets testing cattle were being influenced by their farm clients to be lenient in their interpretation of the results, with diseased animals allowed to remain in herds rather than being removed for slaughter. According to another Irish researcher, farmers lacked an adequate appreciation of the infectious nature of TB, and their role in practising biosecurity and preventing the spread of the disease 'could not be overstated' (Collins, 2006: 373). Elsewhere in Europe, Moda (2006: 254) suggested that non-technical issues had hindered progress in TB control in Italy with delays in reaching eradication meaning that 'the initial co-operation among farmers can be replaced with mistrust and passive behaviour, if not open resistance'. A workshop of TB experts from around the world in May 2013 concluded that better understanding farmer behaviour through further research was the most important step forward in moving towards the goal of TB eradication (Kao, 2013; P. Robinson, personal observation).

Farmers are certainly being apportioned with blame when it comes to the failure to eradicate TB in NI, but to varying degrees. State vets felt that on the whole, most farmers complied with TB legislation, even if they needed 'persuasion' through the threat of subsidy penalties, but their biosecurity practices on farm left room for significant improvement, as one explained:

> ‘Biosecurity, I believe, is a significant issue. Most farmers are complying fairly well with the TB programme in terms of presenting animals for tests. Our evidence is that most herd tests are done fairly speedily before the due date. We have systems which impose administrative penalties to farmers who don't test on time, which helps to encourage them to test on time. In terms of movement offences, yes, we have a scattering of movement control offences, which range from the accidental through to the blatant disregard, and we prosecute where evidence is found, certainly in the latter category ... So are farmers complying? Yes, I think by and large they are insofar as the statutory requirements are concerned. In so far as best practice is concerned, I think there's a long way to go - biosecurity etc.’ (Int A55, state vet)

But if farmers are to blame for the failure to eradicate the disease in NI, not everyone was sure. One private vet was more uncertain about the role of the farmer: ‘I used to think farmers were guilty, but now I'm not so sure [*laughs*] ...’ (Int A19, private vet). This vet went on to emphasize the struggles that many of his farming clients were engaged in to remain viable. Despite the undoubted commitment, farming life has been a struggle for many farmers particularly in recent years, and this chapter will conclude that unexpected or seemingly random disease incursions, particularly of TB, are but one disruption to the state of equilibrium in farming life, if such a state exists. There are other hindrances, but also other opportunities attracting farmers’ attention: we must survey the wider scene to understand ‘the practice of everyday life’ (de Certeau, 1984) in cattle farming today, and agree with Messer (1987: 238) that ‘the structural forces underlying decision-making processes are as significant as the technical problems and solutions’. Blaming farmers for the ongoing spread of TB should not be viewed in stark isolation from the context in which farming takes place in NI. Apportioning blame without examining the background is overly simplistic: a political ecological view provides a deeper appreciation of context.

The demography of cattle farming in NI

Agricultural production and the agri-food industry are arguably the lifeblood of NI’s economy, and are also at the centre of its cultural economy. A legacy of farming runs down through the generations, and the majority of the Northern Irish population are either directly involved in the industry or are only a few steps away from the land through familial networks.

Central to that agricultural economy is the rearing of livestock, with the high average rainfall and the topography of the land ideally suited to growing grass - Ireland was not poetically named 'The Emerald Isle' by William Drennan (1754 – 1820) without good reason. The importance of agriculture was recognised by the state as it planned future government priorities (Northern Ireland Executive, 2013a), developed economic strategy (Northern Ireland Executive, 2013b), and targeted the growth of the agri-food industry (Agri-Food Strategy Board, 2013). Specifically included are budgetary commitments to TB research for eradication of the disease (Northern Ireland Executive, 2013a), acknowledging its importance in the eyes of the state.

NI had a cattle population of 1.59 million animals in 20,201 herds in 2013 and cattle farming is the main agricultural activity in the Province (DARD, 2013a). There were 16,235 full-time and 12,798 part-time farmers in 2013, with the majority of these involved in the dairy, beef and sheep sectors (DARD, 2014a). The overwhelming majority (96%) of full-time farmers are male, but in addition to the females whose full-time occupation is farming is a perhaps undervalued economy of farming spouses and children who work on farms in a supporting capacity, often doing bookwork and helping with practical tasks as needed. As described in Chapter 2, a few of these farming spouses contributed to my ethnographies, either being directly involved in the interview, or contributing from the kitchen bench as they listened in on the conversation. Farming very much remains a family affair in NI, and the family farm 'is far from dead' (Brookfield, 2008).

The predominance of the smaller family farms typical of NI dates back to changes in land legislation in the 19th century when land was transferred to sitting tenants and absentee landlord systems were abolished (Moss, 1986). This landscape has been changing for some time: farms are becoming larger and fewer in numbers as farming, particularly dairy farming, becomes more intensive and specialized. The days of keeping cows, sheep, pigs, chickens, and growing potatoes and barley all on the same holding have largely gone. There still remains a sizeable number of part-time farmers who work off-farm, and keep mostly beef cattle as part-business, part-hobby, carrying on the legacy of past generations.

'Halcyon days' in cattle farming

Older farmers spoke wistfully of a previous time when life on the farm in the 1950s and 1960s was lived at a slower pace, and when there was time to enjoy the fruits of labour. Although there was hard work aplenty, and much of that manual and physically demanding, there was a strong sense of happier times with less stress and pressure, and particularly much less regulatory burden. There was also reminiscence about halcyon days of the 1980s and early 1990s when input costs were low and profit margins were high in both dairying and beef production. Many bought land during this period to expand their cattle enterprises and introduced new mechanised milking parlours, and some had been able to service their debts with relative ease even with interest rates of up to 18.5%, paying off loans ahead of time. Even the weather used to be better:

> 'We have worked with bad prices over the years, but I look back on summers when it was a privilege to be in farming - you wouldn't have changed places with the Queen. If the weather would get a wee bit better - but again, that's out of our hands.' (Int A13, dairy farmer)

Benefiting from a strong state-sponsored productivist ethic which created the butter and beef mountains of unwanted produce in the EEC (Grant, 1997), farmers 'made hay while the sun [shone]', and these were spoken of as the best times to be in farming, particularly by dairy farmers. The generous subsidization of production by the EEC was not to be sustained. The introduction of milk production quotas in 1984 and reforms in the Common Agricultural Policy (CAP) subsidy regime, introduced with the explicit aim of limiting production, changed the farming landscape, but not always for the worse.

Despite such subsidy reforms, production in NI continued to expand, and the quota itself became a valuable capital commodity which could be profitably traded (Kirke, 1989). Dairy farmers took advantage of declining milk production in the rest of the UK to buy excess milk quota, allowing them to further expand milk output. Similarly, cattle herd sizes increased through the 1990s, particularly in the beef suckler sector, as farmers found ways of working a supposedly production-limiting subsidy system to their financial advantage without breaking the rules (Robinson, 2006). The dairy industry expanded in scale and became more efficient, with average herd size increasing from 33 cows in 1983 (Kirke, 1989) to 82 cows in 2013 (DARD, 2013a), and average milk yields increasing from 4,603 litres/cow in 1982-83 (Kirke, 1989) to 7,190 litres/cow in 2013 (DARD, 2014a). Fewer farms keep more cows, and those cows produced 1.98 billion litres of milk in 2013 at a market value of approximately £628 million (DARD, 2014a). The equivalent market output for beef cattle in 2013 was £413 million (DARD, 2014a).

The impact of Bovine Spongiform Encephalopathy (BSE), particularly after 1996, had very serious ramifications on cattle farming. The EU's drive to assure European consumers of full animal traceability and food safety in the wake of the BSE crisis dramatically changed the culture of regulation in animal production. With the introduction of the Single Farm Payment (SFP) subsidy system in 2005 (EC Regulation 1782/2003), a new regime of inspection and cross-compliance between environmental protection of the land, the health and welfare of animals, and the assurance of food safety was introduced, much to the distaste of the majority of farmers interviewed.

Global markets and productivism

Farmers were conscious of being part of an industry and a market which reached far beyond the shores of Ireland's coastline. Watts and Goodman (1997: 3) state that 'the food economy is increasingly driven by global demand and internationalization of the agro-food industry'. The trend of the late 1990s has continued unabated, and farmers, particularly dairy farmers, were very conscious of their place in a globalized market for milk and beef and with that the volatility and uncertainty that world commodity trading brought to their local industry:

> 'Well, to spend £1M on a set-up for dairying - (*laughs*) I think it's a big risk, because milk is a world market now, and we are depending on someone else's disaster so that we get a price. New Zealand affects us - at the minute in New Zealand there's been a drought.' (Int. A13, dairy farmer)

Whilst the farmers wished no ill on their peers elsewhere in the world, drought in New Zealand (NZ) brought hope in NI; a shortage in one place afforded opportunity in another. Several others also spoke of New Zealand's dairy industry, the largest exporter of dairy commodities in the world (Fonterra, 2013), and their focus on how markets in the Pacific affected their returns and profit margins in the north-west corner of Europe. Using the internet to keep in touch with trends in milk prices in NZ, farmers were able to project their own financial returns in forthcoming dairy auctions in the UK; one appeared to follow the other. They also saw NZ, although it has a much bigger dairy industry, as their main competitor in global markets:

> 'The world's a small place now. New Zealand, even though it's on the other side of the world, is a big problem to us, trying to keep ahead of them or trying to keep abreast of them.' (Int A24, dairy farmer)

In both jurisdictions there is an almost complete reliance on the export of the milk and milk products produced – 95% for NZ (Fonterra, 2013), and over 80%

for NI (Dairy Council NI, 2013). Like the NZ dairy industry (Jay, 2007), there remains a very strong focus on increasing production, production efficiency, and expanding market share amongst Northern Irish farmers.

But the focus on markets was not just at the global level; there was also a focus on the EU, with changes in subsidy and quota regimes changing market conditions, particularly with the abolition of milk production quotas on the horizon in 2015. The neighbouring Member State – the ROI – was therefore seen as a threat if, as expected, Irish farmers took the opportunity to expand production without the constraints of quotas, and risking over-supply in competition for similar markets. On a different scale, UK supermarkets were seen as being a major determining factor in prices for beef and milk, and there was frustration that farmers lacked bargaining power and had to settle for being price takers. Added to the mix were the milk processors, and after a period of relative stability and unity there was now increasing fragmentation amongst farmers regarding who they decided should purchase and process their milk. Such is the modern complexity of world dairy markets: the global becomes the local, and global trade networks produce a rescaling of markets through a form of 'glocalisation' (Swyngedouw, 2004).

On the beef side, the mood was much more depressed than that found amongst dairy farmers. Beef prices were at a low point in late 2012, and input costs had increased rapidly, dramatically squeezing profit margins. Prolonged periods of wet weather had also reduced feed supplies. Efforts were being made to cut costs, and there was a sense of despair and helplessness; of matters beyond their control. Considering the future, one beef farmer echoed the views of others:

> 'I would be gloomy about it. I would be gloomy because we can't control our end price - between the supermarkets and the meat plants … Our input costs have become colossal, and the weather is another major hazard. If we get a few more years like this there will be a lot less stock, because people have housed cattle in July and August, and they don't have enough silage, and they are buying more and more meal, and it is more and more expense … Farmers are making a gross profit from suckler cows,

> but once you look at the net profit very few farmers are in a positive situation.' (Int A53, beef farmer)

Despite the uncertainty about the future and instability in the markets, dairy farmers were on the whole optimistic about the future, and many had invested heavily in new technology such as robotic milking machines and new milking parlours, and had expanded their herds to produce more milk more efficiently. Land was stocked to near maximum efficiency, and acquiring new land was seen as the most limiting factor to production, as we shall see when we consider the non-human materiality and ecology of TB and its control (Chapter 7). Lowe *et al.* (1993: 221) defined productivism as 'a commitment to an intensive, industrially driven and expansionist agriculture with state support based primarily on output and increased productivity'. Living with constant volatility appears not to have restrained the productivist instincts of the NI farmer, and the countryside continues to bear the traits of an industrialized space (Bowler, 1985), albeit one that is now highly regulated through environmental protections.

Whilst O'Connor (1993) thought that a 'sustainable capitalism' was not possible, the farmers I interviewed would probably disagree; but they certainly had to work harder to transform the materialities of nature into profit. As with the farmers surveyed by Walford (2003) more than a decade ago in south-east England, productivism in NI is alive and well. Its death was prematurely declared, as others have previously argued (Evans *et al.*, 2002), but this comes with a human cost. Coping with bigger herds, more land, and higher input costs, fourteen-hour working days with one week off per year and pressures on profitability were commonplace on dairy and beef farms. If labour was being exploited on family farms, it was surely 'self-exploitation' (Galt, 2013b), as one beef farmer described: 'Everybody is going like the hammers, like a cat chasing its tail' (Int A1). Many, it seemed, were still firmly attached to the 'agricultural treadmill' (Ward, 1993). As Pile (1990: 136) found with dairy farmers in Somerset even back in the 1980s, ‘the reproduction of the family farm is becoming “harder and harder” and they are beginning to wonder where this work treadmill will take their farms’. These farming trends are therefore long-term, and jumping off the treadmill does not appear to be an option. Speaking of the frustrations of dairy farming, one young farmer said:

> ‘You have invested a *pile* of money, and you need to keep investing, and at the minute you are really just scraping through - you haven't money to re-invest really ... You'll always get those few boys at the top that are doing really well; then there's the average. If you can push yourself towards the top there's more money to be made.’ (Int A8, dairy farmer)

The work ethic is very deeply ingrained, along with a stoical determination not to be defeated. But despite this determination to succeed, maximising profit is not the sole motivation, and the farming *lifestyle* is very important to farmers. As Howley *et al.* (2014) note, ‘it’s not all about the money’. Family farming is more complex than that:

‘Farming is much more than an occupation: it is the reproduction of the family; it is work; it is their public role; it is their social status; and, it is their self-image. These multiple layers of meaning combine in such a way that the work of farming becomes an end in itself and survival its own logic’ (Pile, 1990: 160-161).

As the next section shows, farmers love what they do, despite the hard work and pressure to increase profit margins.

For the love of farming

Culture is an important part of farming. Vets spoke of the different cultures of farming that they experienced in different parts of the country, and there was even a reported difference in attitudes between dairy and beef suckler farmers. Life is lived at a more hectic pace on dairy farms, and there is often a more focused business mentality, with time pressed and precious:

> ‘It depends what areas you are in. Funny, I was in the dairying area and it was all very bizz - it was very like NZ - it was all like “Come on now, the accountant's coming”, or “I'm off now - there's the vet coming now to do the metabolic profile” and all this craic, and all very bizz, bizz, bizz, and you wouldn't be asked in for a cup of tea there - you would just be [*makes whizzing noise*] - out.’ (Int A43, state vet)

In contrast, beef suckler farmers were thought to be friendlier and more hospitable. Invitations to the kitchen table for cups of tea and a chat were frequent, and this was viewed by state vets as an important aspect of smoothing the process of delivering unwelcome news to the farmer and persuading a farmer to do what he may not initially want to do to comply with legislation. There was an emphasis on building relationships of trust, and assuring the farmer of empathy in difficult circumstances.

Despite the constant pressure of work and shadow of uncertainty that most full-time farmers were living under, most still enjoyed being farmers, and only one of the forty-seven that I interviewed appeared to wish he was in a different job. There was a great interest in breeding and rearing cattle; in maintaining and harvesting the land; a love of the outdoors; and enjoyment of manual work. Most said that they had grown up wanting to be a farmer, and for many, that desire and work ethic was nurtured by their father and even grandfather, from their schooldays. Farming was in the blood:

> ‘When I was at school all I could wait for was the bell going at 3.25 so that I could get home as quickly as I possibly could. Having to stay 40 minutes extra to do games absolutely ruined that afternoon for me. I just wasn't interested in sport - all I was interested in was work.’ (Int A22, dairy farmer)

> ‘I've been farming since I left school, in fact I’ve been farming since *before* I left school, which is longer than I care to remember, and I love farming.’ (Int A50, dairy farmer)

There was a strong sense of carrying on the farming legacy, which may have stretched back several generations on the same farm, and the land and continuation of the herd meant everything. There was concern amongst some that farming sons were leaving the land and looking for better working conditions and pay elsewhere. Several expressed the opinion that the burden of regulation was dissuading their sons from wanting to farm. The collapse of the building trade with the financial recession of 2007-2008 had encouraged some to return to the farm, perhaps because they had few options elsewhere.

Many farmers spoke in glowing terms about the 'beauty' of their cows; aesthetics were important. Asked what he most enjoyed about dairy farming, one farmer in his 40s replied:

> 'I love going out there in the morning and the row of cows standing down the parlour and the udders are full ... cows bred the way you want them to turn out. I suppose any farmer with stock - you always go back to the basics, you want a nice cow and that's the thing that is the icing on the cake. If the stock are there and the stock are good, there's a certain amount of satisfaction out of it ... I enjoy admiring my stock.' (Int A16, dairy farmer)

This pleasure in looking at cows 'bred the way you want' was repeated by others. As he spoke, the bull catalogue sat open in front of him on the table – the next batch of semen was under consideration, judgements made on stud photographs as well as production figures. The innate desire of a farmer to see the cattle produce and reproduce was also applied to the land:

> 'I like the spring time when you look out across the fields and you see the way the grass is growing, before the fields are all grazed. There's a certain perfection about the whole thing, and I get a satisfaction out of that. You put your fertiliser on; you put your slurry on; and you roll your fields; and that certainly would please me.' (Int A16, dairy farmer)

There was therefore a pride and intimate knowledge of both the cattle and the land which produced the grass to feed them. This 'knowing' was extensive, both of cows and land. I often asked dairy farmers how much they could tell me from memory about any particular cow chosen at random from the herd. The following conversation was very typical:

> PR: 'How well do you know your cows?'

> 'Oh, I know them all [*very confident*]. If I only saw a wee bit of any cow I could tell you its number.'
>
> PR: 'Really?'
>
> 'Oh yes. I remember everything about them.'
>
> PR: 'What else do you remember?'
>
> 'I know roughly when they calved, and I know whether they are in calf, and I could probably tell you what bull they were bred from, and near enough what age they are, and nearly a whole history about any cow.'
>
> PR: 'You have 90 cows?'
>
> 'Yes.' (Int A9, dairy farmer)

Farming is seen as both a business and a pleasure, but the balance between these perhaps opposing descriptions is moving more towards business than lifestyle choice for younger farmers. They were seeking more leisure time than their fathers had been accustomed to, and using technologies such as milking robots to reduce hands-on labour requirements, and this was changing everyday routines. One dairy farmer who previously worked daily from 5 am until 8 pm spoke of the change that the robot had brought to his daily routine:

> 'This morning I was down here about 7.45 am - I got up about 7 am and checked my emails on the iPad [*laughs*] - which is some change as well - had some breakfast and came down here about 7.45 am ... If everything goes smoothly through the day ... you could be leaving here as early as 5 pm.'
>
> PR: 'So it has made a huge difference to your social life?'
>
> 'Oh, it has. The only thing is that you are always on call 24 hours a day. The robot could phone you at 3 am, and if so, you just have to respond to it, but if you were wanting a weekend away it's a matter of putting my worker's number into the dialler or my son's.' (Int A22, dairy farmer)

Rather than being enslaved by the milking parlour, the milking robot demanded a new type of subservience, but he appeared more than happy with his new 'master' – the robot's computer (Holloway *et al.*, 2014). It allowed the farmer to experience a social and a family lie which he had never experienced before, and he liked it.

Knowledge acquisition and transfer

In addition to being both a business and a lifestyle, the farm is also a seat of learning. Farmers are lifelong learners, always keen to acquire new knowledge to improve their farming methods. Interestingly, much of that learning is informal and spontaneous, and from multiple sources. There was a very positive attitude towards innovation, and that was found across the age spectrum, with an oft-shared experience of 'learning something new every day'. Knowledge acquisition, both formal and informal, was seen as empowering and enabling the ability to 'think for yourself' (Int A30, dairy farmer). It was also the means of assessing the validity and usefulness of information being peddled from multiple sources in an information-saturated world. All farmers read the farming press during meals or as a form of relaxation in the evenings until bed-time, or even sitting *in* bed – a mixture of acquiring business knowledge and leisure activity. A few said that their spouses read the press and pulled out the relevant parts for them to save time. Many never switched off thinking about farming, single-mindedly desiring to become ever more expert in their field, seeking to improve both their herd and their land. Farmers were keen to tell me about their acumen in the science of breeding and feeding cattle, often using the knowledge they had acquired from other experts, such as nutritional advisors:

> 'I have a fellow who comes here and works on nutrition, and it really boils down to food conversion efficiency. My cows would be averaging about 8,000 litres, and would be well above baseline on butterfat and protein, and the calving index is there or thereabouts on where it should be. After that it's like golf: "Driving for show and putting for dough". If I fed 2.5 tonnes instead of 2.3 tonnes, I would move those cows easily up into the 9,000 litre bracket, but I would very, very soon see that my meal bill would be taking up too much of my milk cheque.' (Int A23, dairy farmer)

Working with fine margins between profit and loss, farmer expertise should not be underestimated, nor should their embodied knowledge be undervalued. The farmers I interviewed were proud of their expertise, and confident in their own abilities, often honed over a lifetime in farming. Many rated their skills in disease diagnosis as comparable to vets, and indeed many used a vet only as a last resort to avoid 'hefty bills' (Int A1, beef farmer). Vets were used by some as a last resort if all else failed, but others were keen to work alongside their vet in herd health planning in a partnership approach, regarding vets as fellow professionals whose businesses overlapped with mutual benefit.

Although informal education and learning was highly valued, the majority of younger farmers under the age of forty had some form of agricultural college education. They had varying opinions on its usefulness. Whilst some valued the extra skills acquired in business management, information technology, and general life skills, others thought that *practical* experience working on a farm was of more benefit than classroom-based education. These farmers emphasized the embodied expertise and knowledge gained from following and imitating their father, the one who was passing down the skills of his and previous generations on the farm. This tied in with the common emphasis on legacy in farming.

In turn, farming fathers whose sons had followed them into the business were keen to see their sons get a college education before coming back to the farm full-time, and they saw this as a way of introducing new skills and expertise to keep up with the times. For example, one father very proudly spoke of his son and the benefits that his college education had brought to the farm in terms of knowledge of handling and applying farm chemicals, performing artificial insemination, and managing herd fertility through computer software – a skill set that he did not possess. Whilst this was *new* knowledge, a retired dairy farmer spoke wistfully of *lost* knowledge, and went back to his old college curriculum when he felt there was a more intensive and scientific schooling in the basic materialities of farming and nature less appreciated by the current generation – botany and grass varieties, for example. Nonetheless, at a time when many agricultural colleges have closed elsewhere in the UK for lack of interest, formal agricultural education is still valued and is expanding in NI.

Farmer networks

Significantly, farmers are also building networks of like-minded individuals to further educate each other in the skills of farming. Several interviewees, all dairy farmers, were members of dairy discussion groups of between 20 and 40 members. These groups were often facilitated by commercial advisors, but the emphasis was very much on learning from each other within the group. Meeting generally up to six times per year, the groups met to discuss a wide range of farming topics, including animal health, silage management and financial matters. Built on confidentiality and trust amongst peers, these farmers shared their practices and know-how, with practical visits to farms combined with studying farm performance statistics.

Murdoch and Ward (1997: 320) suggested that the British government in the 1990s wanted to promote 'forms of calculation and self-regulation that would teach farmers to see themselves as modern business people.' Now farmers, particularly dairy farmers, are doing this for themselves – meeting regularly to compare statistics and share expertise together, creating their own 'knowledge networks' built on trust and 'shared community of practice' (Sligo & Massey, 2007: 178):

> 'We do our figures together, but then we discuss our figures together too. Obviously it's confidential, but we can see each other's figures, and see *how* each other are doing, and see *what* each other are doing. I would say at the minute it is my main source of education ... in dairy farming ... You never go to a meeting where you don't learn something from somebody.' (Int A8, dairy farmer)

In addition to inviting guest speakers to teach the group on the topics under consideration, their geographies and horizons were not limited to the local, but they learned the geographies of dairy farming in other parts of the UK and the EU through farm study tours. These tours were seen to benefit the group by combining learning from others outside of the group, with a strong social and brotherhood element within it. By experimenting with and adapting the proven practices of others, there was a spirit of enterprise and 'trying out new things' (Int A22, dairy farmer) to fit the specific circumstances of the local farm. Ramisch (2011: 282) describes this process of experimentation as a 'performance,' where farmers improvise their behaviours to deal with the unpredictability of nature 'within the domain of their own evolving knowledge and abilities'. Being open and honest about one's weaknesses and strengths was seen as key to the learning process amongst members.

This willingness to learn from other farmers was not solely limited to those who were members of dairy discussion groups, but rather this attitude was widespread. Some spoke of how the best year of their college education was the sandwich year spent working on a farm; others spoke of farm visits to 'Focus Farms'; and talking to neighbours and friends was also often mentioned. The advice and opinion of peers was often sought on matters of animal health – vaccines and medicines - and before purchasing new technology. This advice was thought to be unbiased and proven to work in the 'real' world. Such topics were even discussed at social and community events: 'Farming always comes up in the round of talk you know' (Int A5, dairy farmer).

The livestock market was seen as an important place to meet other farmers to engage in 'farm talk' about the weather, cattle prices and keep up-to-date about what was happening in the local area. Some went to the market to gauge their own stock's quality before selling, or to assess price trends before purchasing. One interviewee had visited the market on the morning of my interview, and in the two hours he spent there he estimated he had spoken to between 10 and 12 farmers, including several he had never met before. Animal health was part of their conversation:

> 'One guy said all his cows started to cough in August and he did them all with [a deworming medicine], and now they've started coughing again. The other guy said "Have you them dosed for IBR?" ... We all try to learn from each other ... If you talk to people about their problems or your problems you might get ideas. It lets you know what's going on, rather than just going to your vet and asking them all your questions about diseases.' (Int A9, dairy farmer)

For those who valued trips to the market, it was a social occasion to meet the farming fraternity, rather than just an occasion to buy and sell cattle. This was seen by some as a way of counteracting the potential loneliness of farming on your own, particularly helpful for older farmers. But the more business-focused farmers saw such market conversation as 'gossip', and not useful to improving their business.

Farming figures for profit

Knowing figures was described as an important part of a modern dairy farmer's life, and viewed as part of the 'science' of farming. Agricultural college education was felt to emphasize the importance of enumeration and statistics – figures, accounting and benchmarking, the comparison of production figures against peers:

> 'Anybody who goes to [agricultural college] ... they are taught what benchmarking is, and how it operates, and why it's important. Having said that, I don't benchmark, but [*laughs*] I think I have got a pretty good handle on what's going on without doing it. Definitely the younger generation are more focused on figures. There a lot of figures that are used now by Department [DARD] guys - so many kilos of dry matter, and how much dry matter a cow eats, and how many kilos of dry matter per hectare of grass are out in that field. I couldn't tell you those figures, but I could take a quick walk into the field and out again and tell you how long it will feed the cows.' (Int A9, dairy farmer)

The need to discuss figures and sharpen business acumen was necessitated by narrow profit margins, and farming had become a science. When asked about why this was, one farmer suggested that the next generation of farmers were ‘going nowhere without it [the scientific approach]’ (Int A36, dairy farmer). Despite his own cautious approach over the years to investing carefully in his dairy business, he was willing to let his two sons expand and develop the business with an increasing dependence on science, especially in dairy nutrition and fertility management. This necessitated employing expert advisors (vets and animal nutritionists), but many farmers were willing to use their own, and their peers’ lay expertise to ‘know figures’ to maximise profits, mainly through the discussion and buying groups. There was also an element of competitiveness between farmers as they ranked themselves based on their farm figures, affirming there is both power and trust in numbers (Porter, 1995):

> ‘We have a meeting coming up with [milk processor]. They want to hear the farmers' side of this year as far as milk prices etc. go - but they want it backed up with figures, what it costs to produce the milk. Generally they are farm meetings, but once a year we meet to discuss the financials. If you have the best or worst feed rate in the group they will ask you what you are doing. If you're the worst it's a rap over the knuckles [*laughs*].’ (Int A8, dairy farmer)

But farming figures were also a part of farmers’ lay expertise, and applied in practical, embodied ways. A cattle dealer spoke of his skill in calculating his profit margins ‘on the hoof’ (A21), and a beef farmer spoke of the science of deciding what type of animal to buy next time he went to the market based on previous calculations (A7):

> ‘When I was buying those beef cows I could have gone to a yard and I could have said to myself “That cow is *x* kilos dead. She’s not a top-grading cow, but she's not the worst. She'll not make £3 [per kilo], but she's worth more than £2. She's maybe 240-250 kg ...’ (Int A21, cattle dealer)

> ‘I follow every one of the animals through from when they are bought right through to the day they are slaughtered ... They will be counted individually [that] night to see if there is any money left after feeding costs ... if the animal didn't earn money, or didn't earn a lot of money ... and you study the animal - what it was; did it thrive well; or did it not; and where you bought it; and what it cost. So it's a learning process ...’

PR: 'Yes, it's a fine art.'

'It's a *science*.' (Int A7, beef farmer)

But the science of farming is not just used by farmers and their expert advisors to maximise profit. Science, numbers and technology have also been increasingly used by state and supra-state regulatory bodies to govern farmers in their management of land and livestock (Lowe *et al.*, 1997; Jokinen, 2002; van der Ploeg, 2008; Singleton, 2010; Singleton, 2012) in return for subsidy payments and the 'right' to farm.

Paying the price for subsidies

Direct government intervention in agricultural economies is a feature of production in countries around the world through direct or indirect support, and this has been the case stretching back thousands of years. The fundamental principle of agricultural support in the EU was established through the Treaty of Rome in 1957 which founded the European Community (EC, 2002), with Articles 33-39 forming the *Common Agricultural Policy* (CAP). CAP spending in the EU used some 44% of the total EU budget in 2011 (European Commission, 2013), and is therefore a very significant proportion of overall EU expenditure.

Direct subsidy payments are made to farmers which are 'linked to compliance with rules relating to agricultural land, agricultural production and activity' (EC, 2003), but non-compliance means that 'Member States should withdraw direct aid in whole or in part on the basis of criteria which are proportionate, objective and graduated' (EC, 2003). Seeking to remain compliant rather than face the often severe economic penalties of non-compliance, the SFP inspection system appears to have become all-encompassing in the lives of many farmers, and has affected the attitude of farmers towards the DARD Veterinary Service in NI, and DARD in general.

Farmers therefore had mixed views on the benefits of the subsidy payments. For some, these were a lifeline which ensured they could remain in business. One farmer suggested that the subsidies were so important they were NI agriculture's net profit each year. There was a sense of dependency on subsidies as an essential economic support to ensure farm viability. This view is supported by an Irish study by Howley *et al.* (2012) which found that subsidies were supporting otherwise unprofitable farming enterprises, particularly in the cattle rearing sector, and direct subsidy payments could account for more than 100% of total farm income. Subsidies were also seen as a benefit not just to farmers themselves, but to society in general through lower food prices for the consumer. Several said that they would prefer to farm without 'hand-outs', but that they would need to receive better prices for their produce. They felt that consumers would have to accept an increase in retail prices before such a scenario could realistically be introduced. For others, subsidies were justified by the need for European cattle farming to be able to compete with NZ and other intensive cattle-producing countries outside of the EU where production costs were lower, and beef and milk could be more competitively priced in global markets.

Beef farmers were much more dependent on subsidies than their dairy counterparts. A few dairy farmers admitted that they could farm profitably without subsidies, and although the subsidies were a welcome addition to their farm returns, they had built their own particular farming model outside of a subsidy-dependent framework, with the expectation that subsidies would be phased out over the longer term. Asked what he thought of subsidies being abolished in the UK, as they had been in NZ, one dairy farmer said:

> 'That would be great if the rest of Europe did [it]. We can't do that while we are tied up to the rest of Europe. I would quite happily ... I would far rather see it, because nobody would have any gun to my head anymore. I would rather [*laughs*] be farming with no subsidy, and nobody hanging on me, but at the end of the day it would only work if it was Europe-wide.' (Int A28, dairy farmer)

As far as farmers were concerned, the downside to receiving subsidy payments was the system of regulatory control which had been built by the state and the EU to ensure financial probity, compliance with the rules, and the prevention of fraud. Farmers universally spoke of ‘paperwork’, ‘red tape’, ‘bureaucracy’ and ‘control’, and they labelled the system as ‘crazy’, ‘obscene’ and ‘a gun to the head’. Some younger farmers were pragmatic and accepted the system as the price that had to be paid to ensure that EU monies were fairly distributed and that standards had to be maintained to ensure food safety. But for the majority there was a sense of resentment and a climate of fear of financial penalty for infringing the rules, which could mean thousands of pounds being deducted from the SFP payment. Similar fears have been echoed by farmers across Europe (Aistara, 2009; Juntti, 2012) under the weight of the ‘regulatory state’ (Walby, 1999) or ‘suprastate’ (Jokinen, 2002) that is the EU, operating at varying scales and spheres of governance.

‘Paperwork’ and ‘red tape’ - figures for regulation

Supporting the EU and state governance regimes are the statutory obligations on farmers to document their farming in words and numbers. ‘Paperwork’ is therefore a key feature of everyday life in modern cattle farming. Keeping records of calf births and deaths; notifying movements of animals; recording medicines and fertiliser use; filling in subsidy claim forms: farming life is built on a foundation of paper records or their electronic equivalent. To young farmers who know nothing else, this is just part of life; a daily chore which has to be done along with paying bills and filing receipts for the tax return. But to the older generation, this paper-work is an unwelcome burden which is viewed as holding them back from field-work, or ‘real’ farming. To those who left school at the earliest opportunity to farm the land and raise livestock, this is a distraction, an irritation, a bind, and to some: ‘absolutely atrocious’ (Int A13, dairy farmer).

Paperwork was seen to be adding to the pressure of an already stressful and busy life, and contrary to all that they enjoyed doing in their working life:

> 'PR: So you find the paperwork creates a lot of pressure for you?'
>
> 'Yes, because ... the likes of myself left school when I was fifteen, and wasn't interested that much in education, so I wasn't educated for paperwork, and as I have got through life I suppose I have sort of half-educated myself, but I'm not that type of person - I left school to farm, I didn't leave school to sit in an office. That's what they're trying to make us do these days - are making us do indeed.' (Int A29, dairy farmer)

Paperwork was necessary to satisfy inspectors, and there was a criticism that satisfactory paperwork had become a substitute for reality in the field: if it looked right on paper it mattered less what the animals or the land looked like, they suggested. For some, paperwork was beyond their ability to understand, and they employed someone to keep on top of it; indeed, a mini-industry had grown up around filling in subsidy claims forms. These professional 'form-fillers' were seen to be the best way to avoid penalties for clerical mistakes on the form and the avoidance of heavy fines. Some felt frustrated that when the state made mistakes, these were remedied 'with the push of a button', but farmers who made mistakes in paperwork were criminals who were penalised with stiff fines and their integrity was questioned:

> '... Now they say that you are guilty until proven innocent ... but you know, again, that's regulations. I think Europe has a lot maybe to answer [for] on that front ...' (Int A3, dairy farmer)
>
> 'You can never fix a mistake you make, but they [DARD] can fix any mistake they make with the push of a button. They don't believe your mistakes.' (Int A37, dairy farmer)

Hall and Pretty (2008) found that the sense of grievance and injustice around such interactions with the state led to a breakdown in trust and disavowal of shared goals in sustainable land management. Farmer resistance is one potential result of perceived 'regulatory unreasonableness' (Bardach & Kagan, 1982). The same sense of grievance came through strongly in these interviews, and many others besides. Chapter 8 will consider more of the effects of the regulatory regime on the governance of farmers and their relationship with the state.

Farmers were united in their opinion that there was too much ‘red tape’ and ‘bureaucracy’ in modern livestock farming, and they called for the regulatory burden to be reduced. They felt that common sense had been ignored, and that the rules were inflexible and overly reductionist. A commonly cited example was the ban on spreading animal manure (slurry) on land between mid-October and the end of January (the ‘closed’ period) to comply with nitrates regulations and avoid environmental pollution through nutrient run-off. The farmers mocked such regulatory science, and suggested that farming to the calendar was potentially worse for the environment. The ‘closed’ period could often have more suitable weather conditions than the ‘open’ period, and they felt that using their own judgement and common sense would produce better results both for them and for the environment. As with van der Ploeg’s (2008: 214) discussion of the constructed ‘global cow’ with its standardised nitrogen outputs, creating harmonised rules for enforcement across the EU is not a straightforward task for the policy maker, and invokes strongly negative reactions from farmers.

In addition to anger and frustration, there was cynicism from some who believed that processors, retailers and consumers would buy their product no matter what rules and standards had been adhered to in its production, and that above all else, price was the determining factor. There is some justification for this viewpoint in the literature (e.g. Harvey & Hubbard, 2013). Rule-keeping was therefore seen as a waste of their time, but they felt forced into it to meet subsidy and supermarket requirements, creating an unwelcome pressure to conform, and for some this removed the joy from farming.

Alongside rules and ‘red tape’ farmers felt that they lived under a constant shadow: the fear of failing an inspection. In addition to the random inspections carried out for animal welfare, disease control, cattle identification, and land claims checks under the SFP regime, there were also inspections for Quality Assurance schemes and various supermarket schemes; nitrates inspections by the NI Environment Agency; and health and safety inspections. This fear of inspections meant that they lived in a state of nervous expectation:

> 'You know it is always over your shoulder - it's what day you're going to have a tap on the shoulder to have another one of these ...' (Int A7, beef farmer)

> 'I dread a brown paper envelope every day the post comes, waiting for the next cross-compliance check.' (A58, dairy farmer)

Comparing the subsidy system to being 'policed like a Communist state' (Int A44, dairy farmer), farmers spoke of oppression and being under heavy discipline. This was taken very personally, and although they spoke of how they tried to smooth the inspection process by being friendly and accommodating to the inspector, they felt that the inspectors often over-emphasized minor infringements such as cobwebs on the ceiling or cracks in concrete floors. Inspectors were seen to be 'unrealistic' and 'too fussy' and farmers expected a degree of latitude and flexibility in the interpretation of the rules:

> 'We know standards have to be made and adhered to, but within reason - I think there needs to be a wee bit of flexibility within the inspectors ... I think there should be a wee bit of leeway, for we are all doing our best, and there's plenty of other//'

> PR: 'A bit of give and take?'

> 'There should be, yes. I think we have all battled with the weather, and we're doing our best ... Unless there's an obvious problem, I don't think we should be too persecuted, because I don't think ... well actually I'm not in a position to say entirely ... but I don't think some of the other European countries are as tight as we are here.' (Int A3, dairy farmer)

Good inspections were ones where the inspector showed 'understanding' and 'common sense' – these were the 'field-level bureaucrats' (Lowe & Ward, 1997) that farmers could get on with. One farmer felt strongly that farmers had been dehumanised as a direct result of the inspection regime, and had been reduced to 'statistics' by the more senior state officials they used to know on a personal level when they were 'on the ground':

> 'The sad thing is that those are good people that were good people on the ground, and when they go to [DARD HQ] they get brainwashed - that is right, they get brainwashed by the men above them, and they lose touch. We all become … instead of people, we are statistics … They are living in there, shielded from reality.' (Int A53, beef farmer)

Inspection discrepancies provoked in farmers a sense of betrayal by the inspector, but the blame was mostly attached to the higher authorities who they believed depersonalised the inspector's report and issued the penalty:

> 'Well, they go away and tell you that it's alright, but that's only because they pass it on - as soon as it goes upstairs it sort of loses the personal … I mean you can sit here with a guy who has come out and inspected your cows … it wasn't going to be a problem – "No bother, that was great [*with sarcasm*] - that was a really good result." He goes away, it comes back and then suddenly that was a discrepancy that was reported to [the DARD office] or wherever, and your Single Farm Payment is delayed and you are fined.' (Int A28, dairy farmer)

Although ostensibly functioning independently in family farms, farmers are part of a network, and held within a much wider sphere of influence by agribusiness and state interests, as Cox *et al.* (1986:1) stated more than twenty-five years ago, but still very relevant today: 'The farmer is caught in a web of relationships which extends, in one direction to Whitehall and Brussels, in another to the big chemical manufacturers and food conglomerates, in another to the banks and credit companies, and in another to the flora and fauna of natural ecosystems'. Singleton (2010: 249) found similar sentiments expressed on a farm in England in the much more recent past: 'Keeping the livestock alive is one thing. Keeping on the right side of DEFRA, the Environment Agency, the taxman, that's another'.

The farmers I interviewed also found this network of control and governance very frustrating, and there was an acute sense of a loss of personal agency. They thought they were no longer able to dictate the terms of management on their own farm, and felt hedged in by a pressure to conform to the desires of the state or to non-farming rural neighbours with a different discourse on agriculture's benefits to society:

> PR: 'What about being your own boss?'
>
> 'Yes, well you are answerable to ... well, no//'
>
> PR: 'To your brother, your partners? //'
>
> 'Well, no, I was going to say you are answerable to nobody, but you're not, because we've got the Agricultural Police Service of Northern Ireland - the Department - on top of us all the time, so that's the worst thing about farming.' (Int A28, dairy farmer)
>
> 'We try to accommodate them [the neighbours] so we are not a total nuisance, but we are still a nuisance, like every other farmer. If you meet cars on the road, if you look behind you the initial reaction is "Not them again." You can read their lips.' (Int A37, dairy farmer)

From politicians in the NI Assembly and Westminster to the bureaucrats of Brussels, state agriculture officials, supermarket retailers, food processors and even in the wider general public, many farmers felt they had few friends and defenders; no one to stick up for them. The world seemed a rather lonely place for many down on the farm.

Farming stress

With a combination of relentless bad weather over the summer grazing season, and difficulties in gathering harvests and keeping land from being damaged in wet conditions, there was a sense of gloom and foreboding amongst many of my interviewees about the short-to-medium term future for their farm in late 2012. This was to worsen after the winter and spring of 2012-13, when the cold and incessantly wet weather coupled with heavy snowfalls prevented the turnout of cattle to pasture, and provoked a severe fodder crisis. For some farmers, varying combinations of weather conditions, financial troubles, family breakdown, TB restrictions, and regulatory pressures produced a point of no return, and vets spoke of suicides amongst farmers that they knew. One reported how a local priest had counselled six farmers in one week who were thought to be contemplating suicide. Nine months later, the feed crisis in the spring of 2013 created similar pressures on farmers, as an Ulster Farmers' Union (UFU) official explained:

> 'There are obviously other factors [apart from TB] which contribute to those kinds of cases but unfortunately whenever the industry is the way that it is at the moment, all factors point towards not being able to sustain [the farm] and go on ... I mean a farmer who can't feed his cattle can't cope with that - they just can't cope. We are seriously worried. You read about cases [of suicide] in the paper, and it's all too close to home.' (Int A54, UFU official)

One private vet saw it as a very important part of his professional role to act as a listening ear for farmers in such situations:

> 'As a vet I see my role, especially as a rural vet who has been in one place for a long time, you do have a social role - you are part of the social fabric of the rural community ... We don't visit as often, but at least we are there. And I know clients where I am the only person they have spoken to for the week - there is nobody else there.' (Int A48, private vet)

State veterinary officials spoke of coping with farmers breaking down in tears, desperately asking for an escape route from TB restrictions which had stopped their cash flow and crippled their business. There was a strong sense of helplessness and despair in the countryside. Farmers were being referred to rural helplines for counselling and support; vets struggled to know how to respond. TB breakdowns and the eradication programme, particularly the perceived inaction by the state on the culling of badgers, were viewed as part of this complex and stressful mix:

> Vet 2 – 'I think farmers feel they are very much on their own and nobody is really on their side - nobody is doing anything for them, and as you say, if something happened - even if it is only small - we are seen to be doing something [about TB], then the farmers would probably work more//'
>
> Vet 4 – 'They would buy into it a wee bit better.'
>
> Vet 2 – 'They would probably contribute //'
>
> Vet 3 – 'Rather than just being imposed on them //'
>
> Vet 1 – 'A bit of a carrot.' (Int A43, state vets)

But for others unaffected by TB, the disease and its control were almost incidental to farming life. The annual TB test was just a date on the calendar; part of the everyday rhythm of agriculture:

> 'It's hard to say that it's apathy, because it has become a day in the diary, just another day for everybody that you have to do, a job you have to do, like you have to sow the manure - you have to do this ... it's just another one of these days and the vet says "It's TB testing time again" ... and they just go out and fall asleep and just go through the motions.' (Int A19, private vet)

The connection between farming stress and TB was often only *after-the-event* and only when the disease came knocking on the door; but there was certainly much else to drive farmers to despair.

Farming lives – reflections

Bernstein (2010: 304) suggests that 'what the best of political ecology does ... is pose questions about the biophysical/environmental costs of the productive forces in today's most "advanced" capitalist agriculture, and about their social costs'. This chapter has shown that cattle farmers in NI are living with social costs in a climate of uncertainty, sometimes fear, and almost constant pressure. Spectres of market forces, regulations, inspections, paperwork, bad weather and disease hang over them, but they still farm, because it is both a business activity and a lifestyle choice. The majority would have it no other way; they farm because they love to farm. They know cattle and nature through aesthetic and cultural appreciation, but also through the science of enumeration, with a continual desire to learn and know more to better themselves, their cattle and their farm.

There are socio-economic costs within this political economy of agriculture, and as we will see in Chapters 5 and 7, there are also biophysical and environmental costs in this highly intensive industry: disease is one of those costs. TB is partly a by-product of agricultural intensification and productivism, and its control is affected by the political economic circumstances described earlier. Farmers may be held partly accountable and partly to blame for the failure to eradicate TB, but substituting 'TB' for Lowe *et al.*'s (1997:119) case study on 'water pollution', farmers have 'other preoccupations'. Their main focus is the production of milk and beef, and controlling disease is an important part of these objectives, but TB does not always come top of their list of priorities as they struggle to keep their businesses afloat. If farmers are blamed by the state for not paying due deference to TB on their farms, the conditions in which they farm and their alienation from the state may offer partial explanation. Farmers are skilled in adaptation and problem-solving, which may be why they are particularly frustrated by their perceived inability of the state to deal with the ecologies of TB.

More will be said when considering the technologies, ecologies and governance of the disease in Chapters 6-8, but consideration must firstly be given in Chapter 5 to a fundamental question: 'What is TB?' This answer is more complex than it first appears, and the nature of TB also offers further explanation as to why farmers do not always make TB eradication the first priority in their everyday farming lives. As the next chapter illustrates, there are framings of TB as a disease which make it appear to be a problem without resolution.

Chapter 5: What is TB? Framing a disease

In seeking to better understand anthrax more than a century ago, Louis Pasteur and his fellow scientists took their laboratory investigations to the frontline of the farm to conduct 'something that was rather like an ethnographical investigation' (Latour, 1988:77). Their methodology meant that they 'learned from people on the ground … the problems to be solved, the rhythm, the progress, the scope of the diseases to be studied' (Latour, 1988: 76). The method proved a useful one, and having been introduced to the history of TB eradication, and the farming context in which the disease is positioned, it is timely to consider the disease known as TB: what is this disease that the state seeks to eradicate? How is it framed on the frontline on the farm, in the veterinary clinic, in the state veterinary office, in the laboratory, and in the chambers of representative politics? The aim is therefore to be a Pasteurian political ecologist, seeking to 'know disease' by learning from others who see and know and experience it in different ways and by different *framings* on the frontline.

Framing has proven particularly useful in understanding complex environmental conflicts (Shmueli, 2008; Buijs *et al.*, 2011), but it has also been used in human health contexts to study disease epidemics (e.g. Dry & Leach, 2010a; Leach & Tadros, 2014). Framing is defined by Shmueli (2008:2048) as 'a cognitive process whereby individuals and groups filter their perceptions, interpretations and understandings of complex situations in ways consistent with their own socio-political, economic and cultural world views and experiences'. In this way framing becomes a device acting as an 'interpretative lens' (Buijs *et al.*, 2011: 330), and demonstrating how different people can have different perspectives on the same subject (Emery *et al.*, 2013).

In this chapter I investigate these multiple framings of TB, and argue that these are another important link in the chain of explanation. How can governance be exercised in control or eradication if the object is not fully known, or is known in *different* ways; a multiple rather than a unity; an object which is messy, heterogeneous, uncertain and with competing truth claims? I want to follow this disease as it moves through the network, and in doing so find that TB is much more than the 'infectious, granulomatous disease caused by acid-fast bacilli of the genus *Mycobacterium*' of scientific discourse (Anon, 2005: 549).

Bringing the methodologies and literatures of political ecology and STS to bear upon the subject means that we can more fully know this nature of TB. Studying the knowledge productions and circulations between lay and expert actors produce an ethnography of the disease. Although the professionals may profess to 'know better than others the nature of certain matters' (Hughes, 1971: 375), for our purposes it is vitally important that all knowledges and realities of TB - scientific and practical; abstract '*techne*' and earthy '*mētis*' knowledges (Scott, 1998: 311) - are analysed together. In merging STS and cultural geographical scholarship with political ecology, we can better study the politics of knowledge production and circulation (Goldman & Turner, 2011) in this particular case of environmental politics.

Framings of TB cannot neatly be divided by social or professional type or positionality – the boundaries overlap too much between lay and expert, farmer and vet, citizen and state - but there are contrasts between them. Wary of Forsyth's (2003) warning not to uncritically associate framings with different social groupings, I will avoid approaching the classifications and perceptions of TB by actor group. Rather, I will bring similar framings together and investigate TB through the forms and processes of what is observed and experienced by those involved and affected in a dialectical fashion. While humans may differ on how they 'interpret the world they live in' (Mol, 2002: 10), their perspectives on disease often overlap, but also contradict. The aim is also to draw forth alternative framings of the disease which may not register in current discourses. As described in the next section, this is a common feature of political ecology and STS literatures.

Political ecology, STS, and knowledge circulations

As Goldman and Turner (2011: 1) remind us, 'knowing nature is a complex, multiple, and highly political process'. Environmental politics means engaging in a 'politics of knowledge,' with various truth claims, observations and experiences thrown into the melting pot by those who seek to engage with the issue in question. For example, the complex and potentially conflicting knowledge politics of TB have the potential to 'shape contestations and outcomes' (Goldman & Turner, 2011: 2) in the management of this disease, and it is therefore important that the politics of knowledge, and what counts as TB, are identified. As Watts and Peet (2004: 20) point out, 'knowledge, power and practice' are interlinked, but even knowledges themselves may not be 'static or stable'. Keeping indeterminacy at the forefront of the mind can help policy makers deal with such complex diseases (Hinchliffe, 2001).

An emphasis on 'knowledge' is usually not explicitly elucidated within earlier political ecology literatures and has developed more emphasis in recent times (Goldman *et al.*, 2011), but knowledge production and circulation is often present in this earlier work nonetheless. For example, Blaikie (1985: 12-37) asked the question 'Is soil erosion really a problem?' and in seeking to define 'soil erosion' he recognized that there was 'enormous variability in people's perceptions of environmental decline' (Blaikie, 1985: 25). Similarly, Blaikie and Brookfield (1987) debated the problem of 'land degradation' and what it meant. It became necessary for them to 'examine critically the political, social and economic content of seemingly physical and "apolitical" measures such as the Universal Soil Loss equation, the "T" factor and erodibility' (Blaikie & Brookfield, 1987: xix). They acknowledged land degradation to be complex and multi-faceted. However, the perceptions of land-managers were centre-stage in their analysis, and citing Thompson and Warburton (1985: 123), tackling this complexity meant accepting 'plural perceptions, plural problem definitions, plural expectations and plural rationalities'. In other words, they had to accept *multiplicity* rather than uniformity of explanation; accepting that there were no easy and straightforward *single* definitions and management solutions for the problem. As they conclude: 'There may well be competing perceptions and these can be put into the context of the political economy as a whole, in which different classes and groups perceive and use land and its resources in different ways' (Blaikie & Brookfield, 1987: 26).

Political ecology's move towards STS has meant that political ecology scholars explicitly study knowledges and framings and their connections to power (e.g. Forsyth, 2003; Goldman *et al.*, 2011; Robbins, 2012a), accepting there is 'inevitable entanglement' (Robbins, 2012a: 152). STS literatures typically focus on the 'recognition of multiple knowledges and perspectives' (Leach *et al.*, 2008), studying their contexts (Wynne, 1991; 1996), and how they are produced, often under controversy (Jasnaoff, 2004). Fairhead and Leach (1996) challenge critical views of indigenous peoples managing forests in the African savanna, and suggest that policy makers and scientists had 'misread' the landscape – there were alternative framings to be uncovered. Forsyth (2003: 26) demonstrates that the commonly used terms 'desertification', 'soil erosion' and 'deforestation', are 'rooted in the experiences of particular groups over time, and represent only partial understandings of complex biophysical changes'. Fairhead and Leach (2003: x) similarly explore how 'environment comes to be problematized', and how globalized scientific and governance regimes interact with national and local policies and practices. Framing of the issues involved becomes all-important when the politics of scientific knowledge are considered, and they conclude that it is 'created by people and institutions with particular situated and partial perspectives' (Fairhead & Leach, 2003: 13).

The experiences, partial understandings, and political framings that one might apply to a desert, soil, or forest may similarly be applied to disease entities in literatures written and influenced by STS and political ecology scholars. By way of a few examples, Poltorak *et al.* (2005) deals with parents' views on measles, mumps and rubella (MMR) vaccination, and Mulligan *et al.* (2012) investigates the governance of Dengue fever in Malaysia. Leach and Scoones (2013) compare the scientific 'gaze' from maps or databases to the 'gaze from the ground' on Ebola and influenza H5N1. Multiple narratives were also constructed and mobilized in connection with Egypt's response to H1N1 ('swine flu'), and analyzing them provided a 'valuable analytical window onto the politics of knowledge' (Leach & Tadros, 2014).

Rather than deal with the 'purified' (Latour, 1993) forms and realities of TB, I will create hybridized epistemologies of the disease, crossing the boundaries between nature and society, between social and natural science, between the human and the non-human. As Hinchliffe (2007: 102) argues, 'the "thing" about disease is not only the infective particle, it is the relations between the various matters that make a disease'. TB is therefore, I will argue, a more-than-scientific matter of concern, and both the scientific and social constructions of what we are dealing with will be considered through the words of farmers, vets and others who have an interest in this disease, and to move beyond the potentially 'thin simplifications' of 'seeing [TB] like a state' (Scott, 1998: 309). I empirically analyze the perspectives, events and practices of TB using a six-fold framing of the disease: fluid mobility; zoonotic risk; mysterious heterogeneity; vague imaginary; economic cost; and everyday ubiquity. These framings are my own, but are derived from the empirical findings of the ethnographic interviews and so are data-driven. As Law (2010b: 183) reminds us, ‘mattering is being done in a large number of different ways’.

Frame 1: Fluid mobility – infecting, or not

TB is most often referred to as an infectious disease. Indeed the opening line of the NI Assembly’s Agriculture and Rural Development Committee Review into TB declared that it is ‘a *highly* infectious disease [italics added]’ (NI Assembly, 2012a:1). Infections must move, or rather be moved, from one host to the next, albeit at different rates and by different means, *infecting* (or not) as they go. More shall be said in Chapter 7 on the ecologies of TB about how TB moves and infects, but the subject will be introduced here as it is important when thinking of the framing of the disease.

TB is just one form of ‘mobile life’ – there are many others (Clark, 2013). Like the FMD that Law (2006) traces, TB leaks from one place to another, despite attempts to form barriers to stem its flow (Enticott, 2008a; Enticott *et al.*, 2012a). These leaks and movements are multi-scalar: from area to area; farm to farm; cow to cow; from point of entry, to multiple organs within a single body. TB is therefore a bacterial as opposed to a viral (Lavau, 2014) *mobility*, a movement with relations and difference (Adey, 2006). It is a fluid and changeable mobility, making futures difficult to anticipate and prepare for in light of the past and present (Anderson, 2010). TB has the potential to erupt, to boil over, to spill, and TB eradication efforts often seem to be merely keeping the lid on an effervescent tin can to stop over-spill. It is therefore in a permanent state of ‘becoming’ (Anderson, 2006).

TB testing is the tool the state and private vets put their faith in to try to detect presence before it becomes an eruption. If this is done often enough, the lid can be kept on; but it seems an ever-present reality which requires intensive effort:

> 'I met with other people who had constant problems with TB ... One man in particular had been closed for almost three years with TB. Every time he thought he was almost getting out of the situation, and then the thing flared up worse.' (Int A22, dairy farmer)

> 'We did try to improve our control by intensive testing areas and that sort of thing - we tried one or two of those. Doing that did bring the TB incidence down, but the minute you take your foot off the pedal off it goes again. The minute you move away from intensive testing of cattle then the disease rises, which would strongly suggest that you are draining the tank more quickly, but there is still an input going into the tank, allowing the disease to continue in the cattle population.' (Int A61, state vet)

That 'input' is often blamed on the badger, which is a suitable vehicle to move TB from one farm to another. A vet suggested that badger mobilities across farm boundaries created the pattern of TB, a smattering of disease across local networks of farms:

> 'And that would be quite often the pattern that we would see - it tends to come into an area, like say the [-] area. It doesn't tend to come into one herd and spread through that herd - it tends to come into the area and spreads through that area. So if you and I and ten of our neighbours are farming one area - I will have two reactors, and you will have three, the next guy maybe he has one - all at the one time.' (Int A51, private vet)

But TB has a confusing and unpredictable mobility, not just between farms, but also within farms. While most breakdowns have only one or two reactor animals, on other occasions there can be explosive outbreaks involving notable within-herd spread:

> 'My cousin has had a rougher run than we have had. We were closed up for the animal I told you about there, but before that he was closed up, and he had a real bad go - he lost 70 animals in one herd test ... That's because those animals were in[side] ... a carrier must have smitten the whole house (*laughs*), or whatever it was, but the 70 all went away in one run.' (Int A26, dairy farmer)

These explosive eruptions are difficult to explain, and different parts of NI seem to have different frequencies of these larger-than-usual outbreaks within herds. One state vet (A42) put them down to statistical anomalies at the extremes of the expected normal distribution. But another possible explanation is the unexpected co-belligerence of a potentiating agent such as BVDV (bovine viral diarrhoea virus) (Kao *et al.*, 2007) which suppresses the immune system of the infected animal:

> 'You have got a herd of 100 animals, and you get a massive outbreak of, say, 90 animals. Is it feasible that you have got infection, and the same thing might have happened - you might have had one animal taken on the skin test, under normal circumstances, but you have another agent in there, an immunosuppressive agent, and these animals that normally would just have been ticking over have suddenly succumbed to the infection? That could possibly explain these big outbreaks; it doesn't necessarily mean that the place is rampant with badgers.' (Int A33, research scientist)

The patterns of mobility between and within herds are therefore fluid and changeable, hard to predict with any degree of certainty.

But TB does not just have mobilities between herds and animals; it also has mobility within bodies. This mobility can only be detected when the animal is dead and the carcass is opened to reveal what was previously hidden. One dairy farmer (A29) lamented the loss of one of his favourite animals, 'a wee silky cow'. All had appeared normal until the TB test came up positive. She had been inconclusive on the test previously, but this time she was a full reactor, suggesting latent infection which had been there for a while. Condemned and taken away for slaughter, a surprising *internal* mobility was revealed on post-mortem inspection:

> PR: 'But when they opened her up then they found the TB in her, did they?'
>
> Farmer: 'She was rotten with it - they hadn't seen one as bad in a while. It was right through her, and to look at that cow you wouldn't have thought there was a thing wrong with her. I was a wee bit reluctant about letting her go to be honest, because there just didn't seem to be anything wrong with her - and she was the culprit. She should have gone the previous year. They reckon she had a full year.' (Int A29, dairy farmer)

What can be done to curb TB mobility? As these case studies show, the logics and practices of anticipating (Anderson, 2010) future mobilities are rendered difficult, for the past can often be no measure of the future when it comes to how the movement of TB is enacted. While I will look more at the governance of the bacterium in Chapter 8, particularly in relation to biosecurity discourses, suffice to say at this point that barrier formation, or building 'dykes' to prevent overflows, is one means of reducing, or even preventing leakages (Law, 2006). This materiality of protection was described by one farmer who believed he happened to farm in the right place:

> 'I would say my farm is a fairly good example that having a good barrier between you and your neighbour does curb the disease, because we are bounded on one side by the river, and the railway track on another side, and in the other direction there's a small pocket of land which different people rent, but it doesn't touch us directly.' (Int A22, dairy farmer)

Some farmers used land barriers by cutting silage on perimeter fields on the farm, or grazing sheep or growing other crops to prevent cattle-to-cattle contact with potentially infected neighbouring herds, particularly if they judged them to be 'high risk' beef herds which bought in cattle. Others believed in keeping 'closed' herds where they did not introduce animals from other herds or especially markets, but the ideal could be over-ruled if a particularly attractive animal was seen in the sale ring and a spontaneous purchase was made. TB breakdowns themselves often sparked further purchase of animals as replacements for those taken away for slaughter, risking new introductions of disease.

Several farmers thought there was just nothing to be done to stop TB mobilities – it just happened – a stroke of bad luck (Enticott & Vanclay, 2011). This view received little sympathy from one state vet:

> 'Farmers frequently say "Well, I can't control it" ... In reality the only factor that is beyond their control is badger-to-bovine contact at pasture - every other thing is entirely within their control. They can stop that happening at housing; they can operate a highly bio-secure business as chicken farmers do. They could do that, and there will be no risk of their

> cattle getting bovine TB, because it doesn't come with the pixies - it either comes from cattle, or from what people are doing, or from a wildlife vector, and the only one of those that they cannot control is that pasture contact, and the truth is they could probably largely control that too.' (Int A56, state vet)

TB may not move 'with the pixies', and yet what is perhaps most surprising of all is that TB is not always mobile or fluid – in one sense it is static, passive, immobile and immoveable:

> 'But this TB is like a pair of lead shoes - they are *very hard to move*. What is the problem, really? You know ... also, you can't blame the farmers for thinking it's a bit odd, and the vets too, the private vets, that this happens to be the thing that all the money gets thrown at, and "You boys, you vets, get loads of money for this craic - isn't it funny that you can't get the thing to go any faster?"' (Int A19, private vet)

Sometimes its mobilities are just too slow. TB refuses to budge, or moves slower than those who wish its extinction would like; it's like a pair of lead shoes. It therefore is a conflicted mobility, moving sometimes, and remaining passive at others. But what is beyond dispute is that this particular 'mobile materiality' also has the capacity to cause considerable disruption (Adey & Anderson, 2011), but confusingly, not on every occasion.

Frame 2: Zoonotic risk – harming humans

According to scientific discourse, and beyond scientific dispute, TB is a zoonosis – a disease which passes between animals and humans - and therefore has the potential to *harm* humans. Indeed TB control programmes in various parts of the world were first instituted to reduce this risk to humans (de la Rua-Domenech, 2006; Atkins, 2010). Only one colony-forming-unit (CFU) is required to initiate successful infection of cattle by the respiratory route (Dean *et al.*, 2005), and perhaps humans likewise.

Historically, bovine TB fairly commonly affected humans in NI, especially through ingestion of unpasteurized milk, but by 1950 there had been a marked decline due to milk pasteurization and increased efforts to remove tuberculous cattle from farms (Reilly, 1950). If success is measured in absence of clinical disease, it has been successful; only 20 human cases were reported in NI between 1999 and 2012 (Public Health England, 2013).

Whilst the threat posed by TB to humans continues to be mentioned in discourses on controlling the disease in cattle (Robinson *et al.*, 2012b), some have disputed the justification to argue on such a basis (e.g. Torgerson & Torgerson, 2010). Human cases are rare in all developed countries, and mostly due to the recrudescence of infection in the elderly, and the human BCG vaccine is no longer routinely administered to children in the UK. I was interested to find out if my interviewees thought of TB as a zoonotic threat in the 21st century.

Most of those interviewed thought that the risk of acquiring TB from milk, the main transmission vehicle of the past, had been resolved through pasteurization. Added to this were the facts that milk from TB-reactor animals was not permitted to be sold from infected farms, and that TB lesions were rarely seen in cows' udders in modern times, unlike the advanced disease states of history. The lack of human tuberculosis of bovine origin was viewed as a triumph of the eradication programme, and something to be widely advertised to those who questioned its merits as a public health measure. To convince the sceptics, one vet believed that more publicity should be given that TB was no longer a human health issue, and that huge progress had been made in the more than 50 years of statutory control (Int A52).

There was a high level of awareness of TB's zoonotic capabilities, and one farmer who claimed to know nothing about TB knew that it could potentially affect people. Older farmers and vets remembered conversations in the past about people who had acquired TB and some who had died of the disease known in those days as 'consumption'. It had connotations of TB hospitals, and a slow, painful death, and could come from unexpected sources, although this pulmonary case was more likely to have been the human variant of the disease rather than the bovine:

> 'I remember a doctor telling me that his father was a doctor ... and he said there was the old doctors' adage: "Beware of the coughing granny in the corner". Apparently there was a whole family, and the granny was coughing in the corner, and within a few years 10 or 12 of that family had died of TB. People forget that.' (Int A49, private vet)

Attitudes varied on the risk of TB from unpasteurized milk. Vets were certainly wary of drinking such milk, especially on TB-infected farms, and hoped that the majority of farmers would heed public health advice to at least avoid doing so during TB breakdowns. One private vet suggested that most of his dairy farmer clients no longer drank milk from their own herds, and this opinion was confirmed by a farmer who thought that less people were willing to drink it raw. He personally had stopped since his grandchildren began coming to the farm: 'You wouldn't like to give them something which wasn't good for them' (Int A12, dairy farmer). State vets talked of the potentialities from infected milk, and one described an outbreak involving 50 young calves with TB which had been fed on colostrum and milk from infected cows in the dairy herd. If milk was a vehicle for transmission to other cattle, then the potential for humans on the farm was obvious.

But not everyone believed that TB was a zoonotic threat in milk. One farmer and his family continued to drink unpasteurized milk despite a 70-reactor breakdown on their farm, and expressed confidence and pride in the quality of the product his cows produced:

> 'I didn't look at it as a risk - I mean the children ... we all drink the milk. But I think if you are on the milk and you are reared on the milk I can't see what harm it will do you. I have great pride in my milk [*smiles, defensive*] - I'm always getting in the good bands for hygiene and TBC [*total bacterial count*] and cell count, so I have good pride in my milk, and if I can't drink my own milk I wouldn't want to be selling it to anybody [*laughs*].' (Int A8, dairy farmer)

Milk, even if it circulated on a heavily TB-infected farm, could therefore be viewed by this farmer as a wholesome product. An organic dairy farmer felt the same, and drank his milk with no qualms or fears of TB. In fact, he argued that those who did not drink unpasteurized milk were storing up trouble for themselves in not building up resistance to disease in the future, and that pasteurization was a form of over-purification. This agrees with Enticott's (2003: 264) findings of beliefs in 'natural immunology' from unpasteurized milk. Vets spoke unapprovingly of such opinions as 'daredevil', 'superman' and 'macho' attitudes borne through lack of education and ignorance of the risk, or as a risk which could be compared to smoking cigarettes – the risk was always in the future, not a present reality.

In addition to the risk from milk, I was interested in the unseen risk from aerosol transmission of TB. With farmers working daily with their cattle in close and confined conditions, especially in milking parlours, there is a risk of inhaling the bacteria expunged in the expirations of diseased animals with open lesions of the lung. Similarly, vets who test cattle often encounter TB reactor animals, and it would be expected they are regularly immunologically challenged by the infection.

In these cases BCG vaccine was regarded to be protective by both farmers and vets, and a technology to prevent harm. Despite its variable and disputed effectiveness in humans (Evans *et al.*, 2013), those who mentioned BCG generally expressed great faith in its ability to protect in the face of regular exposure to infected animals:

> 'I wonder if I haven't got TB myself seeing as I'm up-close-and-personal with these animals all the time. Of course, I'm vaccinated - that's a foolish one - strike that.' (Int A19, private vet)

A farmer who talked of almost constant episodes of TB in his dairy herd had little thought or fear of acquiring zoonotic infection, partly because it was an ever-present, but also because his BCG provided cover:

> PR: ‘How do you feel during a breakdown when you go out to reactor animals before they leave [the farm]? Are you scared, or worried about your own health, or thinking that this house is infected or anything like that?’
>
> Farmer: ‘Not really - it's so common. A lot of the time we have animals going away and they don't have the disease, but they had a high reading at a test. No, you just get used to it, and I've got my TB vaccination.’ (Int A50, dairy farmer)

Both the statistical and anecdotal evidence would appear to substantiate the low risk of harm from TB, and when asked, vets could not think of anyone that they knew of who had acquired the disease during their careers, except for one whose farm client had been immunocompromised at the time of a large breakdown on his farm. A few state vets thought that BCG in childhood had produced complacency about TB in humans, but they were aware that it was not 100% effective. However, milk pasteurization, better diets and better living conditions were felt to afford protection against disease for most people. Two state vets did express concern for the non-vaccinated children living on cattle farms in TB-affected areas, with one classifying this as a ‘human experiment’ which could have serious consequences for public health in the future (Int A47).

In general therefore, TB was not feared as a zoonosis, or as harm, and was regarded to be low risk by both farmers and vets. A dairy farmer felt there was more risk of catching TB on a flight from Nigeria (Int A58), and given that milk was pasteurized and reactor animals could enter the food chain, a beef producer asked: ‘What's the whole thing about?’ (Int A38). An experienced state vet said that he had never seen a farmer worried about his own health during a TB breakdown, and a private vet seemed to echo the views of his peers:

> PR: ‘How much of a zoonotic risk do you think TB is today?’

Vet: (*Long pause*) 'Small … it's still there.'

PR: 'Do you ever think about it?'

Vet: 'Being honest, no.' (Int A39, private vet)

Such sentiments may be the result of the success of the programme in reducing clinical cases of TB in cattle, and rendering TB 'invisible', but several interviewees warned that abandoning a TB control programme would bring back the days of open, very visible, disease in both animals and humans:

> 'If we just based it on pasteurization and did no more testing we would have a very, very sick badger population, and we would have a very, very sick cattle population, and we would have a very, very sick herd keeper population, because the level would eventually go up in the cattle to the extent that we would have open cases of TB.' (Int A41, state vet)

It may be that viewing TB as *harming humans* may be a historical relic with no basis in the present, but is the potentiality for an eruption of 'sickness' just a few absent tests away from becoming reality? Its harmful tendencies have been largely forgotten by most on the frontline, but every so often it pops up to remind us that TB harms. After all, it only takes a few microbes to set up an infection which has the potential to be fatal: that's powerful.

Frame 3: Mysterious heterogeneity – coming and going

TB control efforts illustrate the messiness and indeterminacy of seeking to 'control nature', and resonate with Latour (2000), Hinchliffe (2001), Bennett (2010) and Clark (2011) as they describe the tendency of things 'striking back'. As Clark (2011: 9) points out, there is an 'inherent reluctance of other-than-human elements to hew to the grids and grooves we humans lay out for them'. This is particularly so when we think of TB's heterogeneous practices of *coming and going*, or to put it another way, appearing and disappearing. Whilst linked to mobility, I classify this as a different framing for the purposes of knowing TB. It may appear to be a binary logic – present or absent – but it is rather more a fluid gradient, and there is a mystique and a heterogeneity about TB's presence which makes it more complicated to know. According to both farmers and vets, arrival is often unannounced from a deep blue yonder:

> 'At our annual test in January ... we lost ... I think it was 42 that first day - all milk cows, and that was a bolt out of the blue, because as I say, TB hasn't been a problem on this farm ...' (Int A8, dairy farmer)

> PR: 'It just appeared on your farm from nowhere?'

> Farmer: 'Yes, it just ... one cow sprang out of the blue, and it had it. They took the cow away, and we were lucky we had nothing else after it.' (Int A37, dairy farmer)

> 'I have had quite a few interesting breakdowns, where the guy has been good for years, buys nothing, has no interactions except along his fence line with his neighbours ... and out-of-the-blue he could have a spectacular breakdown.' (Int A19, private vet)

Others were less shocked by the arrival of the disease, and indeed, as we shall see later, it was a commonplace ubiquity which was almost expected. Warning signs for some were the presence on a neighbouring farm or in the local area, or it occurred with 'monotonous regularity' on the same farm (Int A49, private vet) - every test, it seemed, had the same positive result. As a result, one vet felt that farmers were so used to TB they were prepared for reactors to be revealed at any herd test, but other vets still expressed surprise when they found reactors. This may reflect the spatio-temporal variance in TB herd incidence across the country. For example, a vet in a historically low incidence division said:

> 'When a reactor shows up, usually we do get a surprise: "Good grief, it's there!" ... Certainly any time reactors have come up I've been quite surprised: "Oh, too bad, it's a reactor!" (A49, private vet)

TB's arrival may be a surprise, but is it a 'predictable surprise' (Watkins & Bazerman, 2003) that farmers should have seen coming and prepared for? We have seen how farmers often felt helpless when asked about preventing the mobilities of TB, but influencing this belief must surely be the unpredictability and indeterminacy of its being on farms. One experienced beef farmer (A21), under TB restriction at the time of the interview, explicitly connected this sense of uncontrollability and the unpredictability of the disease's presence during the breakdown:

> PR: 'Is there anything you think a farmer can do to keep TB out of his herd?
>
> 'No.'
>
> PR: 'Nothing?'
>
> 'No, absolutely nothing, no. For how can TB appear in my pen ... if I put 10 cattle in a pen, and one animal has it, how did it get in, and why do the other 9 not have it ... you know?'
>
> PR: 'Yes, so what you are saying is that you are sceptical about how infectious TB actually is?'
>
> 'Yes, it's not spreading. TB should be spreading round my farm - I should have had 17 that week, and the next time I tested I should have had 34 or 44 or 54, you know. But instead of that it drops. If there was some one animal there doing the damage – it should have had all the damage done? Like the whole herd should nearly be ...'
>
> PR: 'So it's unpredictable?'
>
> 'Oh it's definitely unpredictable here anyway: different animals, different ages, different yards, different houses, and some up the road then not related to it at all.' (Int A21, beef farmer)

There was therefore an unexplained heterogeneity about the nature of the breakdown which made no sense, and had no logic, leading to a fatalistic 'script' (Vanclay & Enticott, 2011), and a declaration of impotence in the face of such an unknowable force. The 'scientific' knowledge of an infectious disease was contradicted by on-the-ground reality – the disease was not spreading as he expected it to. Similarly, a dairy farmer and his son were puzzled by the lack of TB originating from a known infected area, and also acquiring TB in an age-group of animal which was against the normal pattern of their breakdown:

> PR: 'So you can't really reason as to where it's coming from then?'
>
> P2: 'No.'
>
> P1: 'There's one place in particular which has been clear time and time again, but it's in a real bad area, and we are always worried about it, and yet it seems to have been ... it's been in the cows, and yet this last time it was this nine-month-old calf with the lesions.' (Int A24, dairy farmers)

TB was linked to particular pieces of land, places which were seen as contaminated and harbouring disease which could strike with force at any time. This potential for 'force-full' appearance (Shaw & Meehan, 2013) in some cases took on almost a spectral and supernatural guise, and 'bad surprises' did happen (Anderson, 2010). A farming family were hoping that 'something' did not gravitate in their direction, but it seemed to be coming too close for comfort:

> P3: '*Paddy Brown* [*pseudonym*] lost 17 in the same week. And *Ken Smith* [*pseudonym*] he only has 30, he lost 12 //'
>
> P1: '// It nearly wiped him out.'
>
> P3: 'That whole area down there, just nearly wiped clean out in one week ... [*hushed tones*] ... So there's something down there done it, you know, there's something really bad down there in that area.' (Int A6, dairy farmers)

If arrival is unexpected and hard to predict, departure can be equally so, leading to perplexity and confusion. There were no answers as to where it came from, why it left, and when it could next appear:

> Farmer: 'It must be at least 8 - 10 years ago [since the last TB breakdown] and even that ... it was a fluke. Five heifers went down and they took them away and it was clear after that again - I was only closed up for a very short time, which was very funny - they just took them away, and I was all clear again.'
>
> PR: 'What does that make you think about this disease? Are you confused?'
>
> Farmer: '[*laughs*] Very confused [*sighs*]. You wonder whether the needles [tuberculin test] are doing any good.' (Int A25, dairy farmer)
>
> 'We don't know where it came from, and I think it seems to be indiscriminate and it can just turn up. Now you are not looking forward to your next test. I never really looked forward to testing, but it's starting to play on [my] mind.' (Int A8, dairy farmer)

Aside from such confusion, departure can also produce a palpable sense of relief for those who have been under state restrictions preventing the sale of animals, and coping with two-monthly TB tests until resolution of the breakdown. One farm which had lost about 70 TB reactor animals and had been restricted for more than two years ended up being overstocked by 200 animals they had no wish to keep. I asked what it felt like to have the restrictions lifted and to be allowed to sell again, and it provoked an emotional response from the farmer's wife:

> PR: 'How did you feel when you got opened?'
>
> 'I was really, really, really excited [*with feeling, eyes sparkling*], but *John* was like [*sighs, shrugs*], it was just another day really, it didn't sink in with him right. But the relief ... [*sighs*].' (Int A27, dairy farmer's wife)

TB was gone, for a while at least, even if it took some time to sink in, but who could tell when it would re-appear? With this mysterious heterogeneity TB appears 'slippery' (Law & Lien, 2013: 366), and multiple narratives frame its coming and going.

Frame 4: Vague imaginary – hiding from view

State vets often expressed their frustration that farmers did not seem to practice 'good biosecurity' in an effort to exclude TB from a herd, and to reduce spread within it after its detection. In short there appeared to be a distinct lack of 'buy-in' to the benefits of TB eradication for the future prospects of the dairy and beef industries in NI. Some state vets thought that the solution was to provide more and better information, and efforts had been made to revamp advisory biosecurity publications provided to farmers. There was also a hope that with a voluntary BVDV eradication scheme underway there would be spin-off benefits for the TB programme. Seeking to answer the 'why' question on the perceived lack of biosecurity, a common view amongst vets was that TB was not a 'real' disease in the eyes of farmers – it was a vague imaginary, a figment of the imagination of the state, and vets in general. This *hiding* was seen to affect farmer and beliefs and behaviour:

> 'If the farmer doesn't believe that it's a disease, a real disease, a real infectious disease, is it any surprise that he won't double fence or that he won't operate a closed herd, or that he won't put [disinfectant] foot baths at each house?' (Int A42, state vet)

> PR: 'What's the farmer's attitude to TB in general?'
>
> Vet: 'I think that ... I think they see it as a nuisance. I think they see the testing process as a nuisance. I think they don't really believe that animals actually have TB.'
>
> PR: 'Because there's nothing to see?'
>
> Vet: 'There's no disease. You know, I've never seen an animal with clinical TB. And the number of clients of mine that have is declining every year - there are some. There are people who do remember the days before TB ... eradication. And I still have clients who have had TB and talk about it, but it's a declining number. I don't think ... I don't think they have any clear view ... you know, it happens, they have to do the TB test ...' (Int A48, private vet)

The very fact that there are very rarely clinical signs in cattle, and disease in humans is virtually never seen, means that farmers may no longer believe in the disease's existence – TB is hiding its presence. In one sense, the TB control programme is a victim of its own success, making it harder to remove the rump of persistent disease that remains. This interpretation was supported by a beef farmer who complained bitterly about having to TB test his large herd on a very regular basis, and he questioned the need for the programme in general. For him, TB was an *invisible* disease, there was nothing to see, and he did not know what to look for anyway:

> 'Those eleven [TB reactors] ... they were all fit and healthy animals, you wouldn't have picked them out, and they went on their way ... If an animal is really sick with TB, what does it show?' (Int A38, beef farmer)

This lack of anything rendered visible contrasted to other diseases more commonly encountered on the farm, as state vets explained concerning BVDV, whose presence was obvious:

> Vet 5: 'Most farmers if they [look] back over their herd over the years they will recall seeing an animal with BVD and the consequences of it. And that's what drove that [BVDV eradication scheme] in the South, because even if you've seen it once you would remember what type of thing it is, whereas with the TB you don't see it //
>
> Vet 2: 'You don't see it' //

> Vet 5: 'In fact, I had a guy there recently there who had a bull, and it was only when he went back in to find out about the post-mortem result it came out that six months before that he was treating the bull for some sort of respiratory condition.'
>
> Vet 2: 'TB is not an illness, whereas BVD is - it kills their cattle.' //
>
> Vet 3: 'That's true.'
>
> Vet 4: 'And it costs them money which they don't get compensated for.' (Int A43, state vets)

When I questioned farmers in the focus group on the 'reality' of TB in their eyes, they denied that they viewed it as anything other than a real disease:

> PR: 'Do farmers actually believe in TB as a disease, or is it a fantasy?'
>
> Farmer 1: 'It has to be a disease, I never heard any ... //'
>
> Farmer 3: 'I never heard anybody ... //'
>
> Farmer 2: 'I never heard of anything other than that.' (Int A58, farmer focus group)

So perhaps it is more complicated and nuanced than the vets believe, or there is a disconnect between what is admitted and what is acted upon subconsciously. There was a certainly a high degree of *disease* awareness in general amongst the farmers interviewed, and vaccination was used widely as a means to prevent or lessen the effects of common endemic diseases (e.g. BVDV, infectious bovine rhinotracheitis and leptospirosis), especially in the dairy industry: 'We vaccinate for nearly everything under the sun' (Int A11, dairy farmer). There was a common 'safety first' approach to protecting their most important assets – the cattle – and minimizing the economic effects of disease outbreaks. But no vaccine is yet available for TB, and perhaps this encouraged a belief that nothing can therefore be done to halt TB mobilities. What also comes into the equation is the economic impact that TB may or may not have on a farm in comparison with other diseases:

> Farmer 2: 'Actually, with biosecurity my first thought isn't TB, my first thought is the other diseases - Johnes and all the rest actually because they have a much greater potential to really affect my bottom line - if I get IBR or Johnes or BVD or whatever - and I vaccinate as much as I can - economically that would have a much greater economic impact on me

> than TB. Those other things would make me think much more about biosecurity.' (Int A58, farmer focus group)
>
> PR: 'Why is TB classified as a different disease in farmers' eyes?'
>
> Vet: 'Because it's a chronic ... no one has demonstrated to the farmers that it's a production disease that is affecting their production. If they lose a reactor, we pay them well for it. BVD is an underlying infertility, scouring, losing weight, production loss - no one is going to pay them for that. Salmonella causes scour or calves dying of pneumonia and scour, and *Salmonella dublin* abortion storms - you could lose milk just like that. Leptospirosis is constantly causing [*losses*] ... so young farmers can understand that a production disease is causing loss of production, and if someone can produce figures for them and say "If you vaccinate, vaccine is going to cost you so much, and if you don't vaccinate disease is going to cost you so much - so which is better?" TB-wise they can't vaccinate - they have to try and control it - but at the end of the day, apart from massive outbreaks, which are not that common, the production loss doesn't merit them wasting their time ...' (Int A47, state vet)

Rather than underestimating the presence of TB or lacking knowledge of the epidemiology of the disease, there may be some degree of calculation amongst farmers that spending money and trying to stop TB is indeed a waste of their time. Discussing the perception of risk anthropologist Mary Douglas (2003: 29-30) states that: 'Apparently, people underestimate risks which are supposed to be under their control. They reckon they can cope with familiar situations. They also underestimate risks which are rarely expected to happen ... Most common everyday dangers tend to be ignored ... neglecting low-frequency events seems an eminently reasonable strategy'.

As described in Chapter 4, the threat of TB on a farm is but one threat amongst many, and TB may be less apparent and less risky than most. Looking outside of TB for similar situations is instructive. Galt's (2013c) study of Costa Rican farmers showed that despite their knowledge of the 'hidden risk' of carcinogenic pesticides, they nevertheless failed to use protective clothing when handling and applying the chemicals. The complex pressures on their time and economic circumstances reconceptualized their approach to personal safety. Political economy produced a fear of losing competitive edge in the 'treadmill of production' from the encumbrances of gloves and visors (Galt, 2013c).

TB, like the carcinogens in pesticides, may be hidden, but it may never appear at all, and even if it does, it can often be coped with, at least for a time. If TB is hiding, many are willing to ignore or forget, because there is much more that is visible, catching the immediate attention, and with more economic impact in the present. With around 94% of herds free of TB at any given time, the risk of acquiring it may even appear low, even when moving in animals from other herds. Purchasing decisions may also be affected by the lack of price differential for the produce of TB-infected farms, as one state vet suggested:

> 'Part of that risk [of purchasing cattle] is bringing in TB, and they're perfectly willing to accept that. I think the reason they are willing to accept that is that meat and milk go out at the same price' (Int A56).

Risk decisions and economic consequences appear to be connected. In a farmer's mind then, an 'eminently reasonable strategy' may be in place to suit the economic realities of modern cattle farming.

Frame 5: Economic cost – hurting, or not

Continuing with the theme of multiple and contested framings of TB, it is important therefore to investigate TB as an economic cost. If TB is *costing*, who pays, who suffers, and who benefits? It primarily costs the state (and therefore the taxpayer), but there is also a cost for farmers, and for some that cost is very significant. The benefits of TB eradication efforts are widely shared between private vets, farmers and the state, but also by the general public in safer food, with overall benefits to the national economy through agricultural trade.

Looking at cost in financial terms, the only figures readily available are the state's cost - £30.9 M in NI in 2012/13 (DARD, unpublished) - and based primarily on the farmer compensation for reactors, the DARD staff employed to administer the programme, and the costs of TB testing by vets in the private sector. Many private vets in rural practices depend on the income they derive from TB testing (considered in more detail in Chapter 6). One state vet accused some private vets of seeing it as a 'cash cow' to be exploited (Int A42, state vet). With many practices earning substantial sums from TB testing, several private vets acknowledged that there would be a sizeable number of unemployed vets in NI if TB was eradicated in the future. Some farmers played on this to suggest that vets were not keen to see TB eradicated.

The cost of a TB herd test for a farmer in terms of his time and labour has been estimated to be on average £78 (NIAO, 2009). All herds are tested at least annually, but testing is only one part of the cost to a farmer, and the total annual cost of TB for all cattle farmers is unknown. It is likely to be sizeable and underestimated when the effects of TB breakdowns are considered – cost can be hidden too. State vets tended to underplay this cost, and thought that most farmers were quite content to receive the compensation. With free TB testing, TB costs were thought to be no more than 'nuisance value', with little incentive for farmers to strive for TB-freedom:

> 'Part of the problem is the fact that when you have different groupings involved - you have farmers who to a large extent are able to do what they want to do, and they have no big incentive. I mean we don't have many people coming to us saying "How can I stop getting this disease, it's really important to me?" because in general they get the compensation, and the testing done for nothing, and to be honest it's probably just more of a hassle than anything else.' (Int A56, state vet 1)
>
> PR: 'Well why do you think they [farmers] don't do that then [practise better biosecurity]?'
>
> 'Because there is no financial advantage, significant financial advantage to a farmer having TB or not. It's nuisance value more than anything ... In reality there is no financial gradient there to make it worth his while not to have TB. I think that's the big problem.' (Int A56, state vet 2)

The conclusion from the vets then was that TB had little impact to farmers in terms of cost, and those trying to argue for better biosecurity protections on farms were facing an uphill struggle. Herds free of TB on a consistent basis had only the cost of labour on the days of the annual herd test to contend with, albeit testing itself could produce some unforeseen costs in terms of injured animals or abortions due to the stress of handling. For those who had experienced short or infrequent breakdowns, there appeared to be minor disruption, and this seemed to confirm the beliefs of the state vets cited above:

> PR: 'And did you have TB in years past?'
>
> 'On and off, but we have never had any more than two or three [reactors], so it has never really had a significant impact apart from the fact you are closed and you can't sell calves. This last outbreak - I'm calling it an outbreak, but it wasn't that major, it wasn't major at all ... We're fortunate enough that it didn't impact on cash flow - we were able to keep going without it.' (Int A36, dairy farmer)

Given that most herds and animals are free of TB at any given time, it could be argued that farmers are behaving rationally in their attitude towards the disease, with outbreaks classed as low frequency events with minor economic impact. As already described, the heterogeneity of TB can produce uncertainties which in turn may affect farmer attitudes and behaviour. Douglas (2003: 43) states that: 'A risky situation is one governed by known probabilities. If not enough is known about the probabilities, we are dealing with uncertainties'. All farmers are inherently risk-takers (even to plant a crop in the spring and expect a harvest is taking a risk) and if this risk-taking logic is applied to TB, the majority may be willing to cope with the uncertainty and make the gamble of purchasing potentially-infected animals, or grazing beside other herds, with the expectation that all will turn out well in the end. The risk of financial catastrophe is lessened by knowing that the state compensation for TB reactors is an insurance policy waiting in the wings in times of need. Added to this is the stoicism of farmers in the face of the uncertain vagaries of farming; they are unwilling to give up easily, and usually hope for better days ahead.

Several vets, especially in the state sector, thought that the only way to achieve better compliance with biosecurity and a more serious approach to TB control was to make farmers pay for the control – either through forcing them to pay for the test, or by reducing compensation for reactors. Examples from other countries were used: in the ROI farmers pay for testing, and in NZ all farmers pay a levy towards TB disease control. Significantly, the NZ scheme is also run by the industry rather than the state through an organization called *TB-Free New Zealand*. Other disease examples were also mentioned, and one state vet used the example of Aujeskzys Disease (AD) in pigs, which he felt was only eradicated from NI when the industry helped to contribute towards the cost. Price penalties on pig meat had also been levied on producers who did not comply with the AD eradication scheme. The market was therefore used as a powerful neoliberal lever to change attitudes and enhance 'co-operation'.

So is TB almost without cost to the farmer? The reality is more complex and contested. Although reactors are compensated at 100% of market value, and all TB testing is provided free of charge to the farmer, TB can certainly inflict significant costs for some. Any herd with confirmed TB will be under movement restrictions for at least four months until two clear herd tests have been completed, and this can cause unwelcome difficulties in farm management with extra animals to feed and reduced cash flow. But the economic cost for others who have been under restriction with chronic infections for several years is of an altogether different magnitude. Even for a herd restricted for one year, given the right, or indeed the wrong circumstances, there is very considerable financial pressure on the farmer and circumstances challenge his ability to sustain the enterprise through tough times. This quote from a dairy farmer illustrated this very clearly:

> 'It has tied us up so much - to go from maybe 360 or 370 cattle on the farm to maybe 530-540 today with bad milk prices, bad weather, inputs rising unbelievably, and the bank's not easy talked to, we have found - it's as tough a year as I remember, and I'm sure it's as tough as daddy remembers. We would say it's our worst year, the money that ...' (Int A24, dairy farmer)

This farmer was under severe pressure from their bank due to the reduced cash flow in an already stressful year, and I interviewed two very depressed farmers that morning who expressed their hope that my research would help find solutions to the cost of TB. Another farmer spoke of living with TB for most of the previous 12-13 years, and how he felt their herd had been ruined after purchasing replacement cows which introduced another devastating disease – Johnes:

> 'I couldn't tell you many years it's going back - maybe it's 12 or 13 years, and we've been nearly continually closed up with TB //'
>
> PR: 'As long as that?'
>
> 'Yes, there was one day we put 80 of the milking cows onto lorries [as TB reactors]//'
>
> PR: 'Wow'
>
> '// which was very tough. And it has, it has ... well, it destroyed the herd. And then we bought in animals, and we bought in disease [Johnes], and we've just had ... it's just never been the same since.' (Int A28, dairy farmer)

Farmers with experience of longer breakdowns told me of how they had to extend their overdrafts under pressure from unsympathetic bankers; build new sheds to house the extra livestock; borrow money from friends to pay bills; buy extra animal feed for months on end; miss out on the price premia of export markets; suffer the loss of years of breeding and herd improvement; and lose production because they were spreading scarce feed very thinly amongst too many. If a sizeable proportion of a milking herd is lost through TB, there is a very significant loss of milk production income. Servicing an overdraft of £0.5M, one farmer

(A32) reckoned that he had missed out on £60,000 of milk sales after losing 30 cows and being prevented from purchasing replacements by DARD due to the severity of the breakdown. Sourcing replacement animals of a similar standard to what was lost through TB was often difficult, and as we have seen, other diseases could come in like a Trojan horse, often invisible until months later. The time and effort taken to breed dairy cows is also lost in the event an animal is declared TB-positive. Farmers emphasized that state compensation monies just do not pay in these situations:

> 'It would be hard to calculate what it costs a farmer, but I know it would be a lot.'
>
> PR: 'So for the Department to say they give you compensation //'
>
> 'It wouldn't look at it. Even if the compensation was three times the price of an animal, I wouldn't want to go down.' (Int A11, dairy farmer)
>
> 'We have heavily invested in getting that calf to hit the ground. It really does stress you out a bit that there's nothing to stop one of these going as a reactor. Or, at the next test instead of having 10 down, it could be 50 or 60. You know? All of a sudden, it's "What do I do then?" It would be a big game changer, so it would. That's more the stress really. It's part of the stress on the business.' (Int A23, dairy farmer)

For most farmers in NI, TB is not costing very much. Alternatively, for the unfortunates who come face-to-face with it, living with rather than living without (Mather & Marshall, 2011) TB for prolonged periods, the financial costs of not being able to trade animals and losing milk output can be very substantial. This does not include the emotional costs, for 'the cost of bovine TB cannot be measured solely in financial terms' (NI Assembly, 2012a: 1). Tears have been shed by some farmers, and deteriorating mental health and atmospheres of despair in the countryside are another cost of the disease that cannot be enumerated (Int A43, state vets focus group). TB therefore *costs*, but in complex and multiple ways. Some have argued that TB does not cost enough to make it be more feared; for others, it costs too much; for most it's somewhere in between.

Frame 6: Everyday ubiquity – desensitizing

As already outlined, for many farmers, TB is part of everyday farming life in NI. The disease has been known for over a century, and the eradication programme, as described in Chapter 3, began in earnest in 1959. TB may therefore be regarded as almost omnipresent in space and time. Elden's work on the French philosopher Henri Lefebvre points out that: 'Lefebvre acknowledges the importance of Hegel's dictum: "The familiar [das Bekannte], just because it is familiar [bekannt], is not well known [erkannt]". Everyday life may be familiar to us but this does not mean that it is understood' (Elden, 2004: 111). And so it is with TB, the disease which is not well known, and not well understood, despite its everyday appearances and familiarity. In a sense, TB *desensitizes* by its ubiquity and confusing un-knowability:

> 'Everybody wants to have a clear test, and if you are down, well, it's a nuisance, but it's an accepted thing, that it's a part of ... it's been going on for a lifetime, but it's one of those things that has gone on and on and has still not resolved. Maybe that's why you're doing this thing [*laughs*] - there's no resolution to it ...' (Int A3, dairy farmer)

Here it is described as 'an accepted thing' with no resolution because it has gone on for years with no end in sight. Some farms have TB 'with monotonous regularity' (Int A49, private vet), and farmers, and vets, may have become desensitized as they metaphorically shrug their shoulders and suggest they have 'bumbled along ... just accept[ing] this is where we are' (Int A56, state vet). For many it seems hard to escape the anaesthetizing effect of everyday reality: it rains a lot in Ireland – and TB keeps coming on back.

Part of the despair stems from TB often being described by vets as 'a multifactorial disease' (Int A47, Int A51, Int A55, A61), leading one vet to cry with exasperation: 'If I hear "multifactorial" one more time I am going to scream' (Int A41, state vet). This has become a commonplace (Myers & Macnaghten, 1998) as the state justifies the reasons why TB has so far escaped eradication amidst rhetorics of complexity.

This chapter has considered not so much the complexity of the factors which come together in the 'web of causation' (Pfeiffer, 2013), but rather the contested framings and narratives of TB. I have been looking at the politics and the ecology of this non-human object and showing that this disease very clearly has agencies and affects which are contradictory and confusing: what are we to conclude? Some think that 'the disease is very straightforward' (Int A61, state vet). But I would argue the opposite: there are different topologies, different spatialities of TB, and 'different versions of what is to count as a stable object' (Law, 2010b: 187), making it a *messy complexity*: 'There is complexity if things relate but don't add up, if events occur but not within the processes of linear time, and if phenomena share a space but cannot be mapped in terms of a single set of three-dimensional coordinates' (Mol and Law, 2002: 1).

This study of the framings of TB reveals how the multiple versions of what TB *is* often perplexes the actors involved. Not everyone is seeing or experiencing the same disease, with 'struggles between different versions of reality' (Law, 2009: 2). What is clear is that these multiple framings go beyond the scientific discourse of an infectious granulomatous disease caused by *Mycobacterium bovis*. TB is a fluid mobility which mobilizes erratically and unpredictably. TB is no longer feared as a threat to human health, but one requiring vigilance and preparedness to continually monitor for its presence. TB confuses – it is a mysterious heterogeneity and a vague imaginary, hiding from view, challenging the state on how to make it more visible, more 'real'. It is also an economic cost, with contradictory and competing valuations and consequences. For many, TB is an everyday ubiquity, part of everyday farming life.

Governance is particularly challenging in such circumstances of multiplicity – what is TB, and why control it? As Dry and Leach (2010b: 244) declare: 'Long wars – against diseases as well as nations – are unpopular'. Perhaps no one really knows *what object* they are trying to eradicate from everyday life on the farm, which narrative to believe, and how to go about it. This is another reason why TB has not yet been eradicated, but revealing the 'multiple realizations' (Peet & Watts, 1996: 37) and 'complementary and additional understandings' (Leach *et al.*, 2010: 375) are important if new governance agendas are to be introduced in the future. I return to governance later in the thesis in Chapter 8, revealing that governance is about more than controlling a disease. In the next chapter I consider the technologies of revealing the presence of TB – particularly the tuberculin test, a 'calculative device' which both frustrates and satisfies (but mostly *frustrates*) those involved at the frontline of TB eradication. For many farmers, TB testing has become the disease - where TB becomes a *practice*, something *done* – and TB testing a reason for state control, even the control of farmers and vets.

Chapter 6: Technologies: testing for TB

'In the discussion of any form of the tuberculin test, certain fundamental principles must be kept in mind. In all work of human hands there is bound to be a certain percentage of errors. The tuberculin test has heretofore been given the credit of being accurate almost to the point of infallibility. While past experience indicates that, properly used, the tuberculin test is exceedingly accurate, it must be admitted that it is far from infallible.'

(Luckey, 1917: 79)

Concluding the previous chapter on the framings of TB as a disease, the point was made that for many farmers the practice of testing for TB had become synonymous with the disease itself. Most farmers first think of *testing* when they think of TB, and this chapter will examine the *technologies* of TB, particularly the Single Intradermal Comparative Cervical Tuberculin (SICCT) test; in veterinary parlance more often referred to as the 'tuberculin skin test'; or colloquially, and most often, known as the 'TB test'.

The TB test is the mainstay of TB detection in NI. It is based on immunological reactions to derivatives of the TB bacterium injected into the skin of the neck of cattle, with measurement of the resultant swellings producing numerical data for diagnosis and classification. It is the appliance of science in the field. This 'technobiological' (Fujimura, 2011) issue has become a central focus of power and justice struggles between the various actors involved in the politics of TB eradication. This chapter will describe the following: how the complexities of the science behind the test; the embodied performance of the test by vets; the contingencies of relations between the lively agencies involved; and the loss of belief have all combined to produce programme failures, despite the efforts of the state to discipline and regulate.

The aim then is to 'turn a technological object [the TB test] into the central character of a narrative' (Latour, 1996: vii), but heeding Latour's advice to simultaneously account for 'human beings with all their passions and politics and

… calculations’ (Latour, 1996: viii) alongside the technological object, for humans are integral to the functioning of this narrative. Whilst not given to following Latour’s propensity to allow the technology *itself* to speak, I allow the humans who perform the test and regulate its conduct, alongside those who present their animals for testing, to speak of it instead. But perhaps this account is more Latourian than might first appear, for as Heidegger (1977b: 312) suggests, technology is both a ‘means to an end’ and a ‘human activity’, and ‘both definitions belong together’. Humans are therefore *part* of the technologies and *instrumentum* (Heidegger, 1977b: 312) of TB. This alliance is particularly relevant in medical diagnosis, where a ‘specific diagnostic ensemble in which bodies, tools and knowledge are mutually configured’ is often observed (Schubert, 2011: 856). Non-humans are also involved – bovines and bacteria, and a panoply of immune cells within bovine bodies. The TB test is therefore more-than-scientific, and like so much of the TB problem, is complex. Perhaps everything about it has become a performance; a drama played out in cattle crushes across the length and breadth of NI. Many actors are involved; not all are happy with the performance.

Technologies in political ecology

Setting the technologies of measurement and data production within a political-ecological framework, I will first provide an overview of how these themes are important in political ecology. While the test is based on science, there is more to the test than the science. This is especially pertinent for those political ecologists who have been influenced by STS and who view ‘science as a social process and [question] claims of objectivity’ (Campbell, 2011a: 48). Nevertheless, this does not mean that such practitioners abandon the use of scientific data and measurement; indeed, following in the footsteps of land use science – an important influence on political ecology (Robbins, 2012a) - many use *data* and *measurements* to back up their arguments. When they do so, they examine the wider contexts of how the data was generated, and what contextualized social processes and discourses can add to the value and shaping of the data (Forsyth, 2011). Whilst these scholars often use scientific data as 'evidence' in their task of challenging dominant narratives and political-ecological outcomes, they therefore question notions of science as value-neutral and fully objective, in line with the classic positions of STS literatures (e.g. Law & Lodge, 1984; Latour, 1987; Law, 2004). As Starr (1987: 47) reminds us: 'In nature there are no numbers. Observers have to create them'.

Far from ignoring or dismissing science then, Forsyth (2011) argues that political ecologists need to engage with positivist science and the universalist scientific measurements which it produces, but to add local values and framings from the people on the ground (such as farmers) to make 'situated environmental science' (Forsyth, 2011:43). In doing so, he believes that political ecologists can help explain environmental problems and their causality, providing alternative explanations rather than merely accepting established discourses provided by policy makers and scientists.

Drawing closer to the subject of this chapter – measurement, data and livestock - Turner (1993) argues that the preoccupation with stocking rates and carrying-capacity models to the exclusion of social processes and consideration of ecological complexity had created false impressions of Sahelian pastoralism amongst environmentalists, and erroneous accusations of 'overstocking the range'. Likewise, Nathan Sayre investigates the origins of the term 'carrying capacity', and suggests that whilst it conveyed a 'sense of calculability and precision' (Sayre, 2008: 120), he questions its usefulness for the management of livestock stocking rates in 'range science' without addressing the complexity created across wider scales and time frames, and without including the human dimensions of cattle management (Sayre *et al.*, 2012).

How do these emphases on data and measurement, and the tools of measurement, apply to studying the subject of TB testing as political ecology? I posit that they are extremely relevant as I look at the discourses and technologies of measurement. The production of numbers by vets as scientific experts and as agents of the state to represent a disease, and how these numbers are received by farmers, merits investigation. Robbins (2003: 235) eschews simplistic categorical notions of knowledge as local or lay versus scientific, expert or positivist knowledges, but suggests that all such knowledges are 'cultural, social, and political', and must be studied together. In doing so, the 'knowledge of experts … is placed under scrutiny simultaneously with that of the herder or farmer' (Robbins, 2003: 251) in looking 'up' as well as 'down' (Robbins, 2002: 1510). The data produced through TB testing is simultaneously ecological, social and political, and the technology used to create the measurements is likewise embedded in scientific but also *social* systems. 'Technology' in its widest sense is therefore a worthy subject of investigation within political ecology. As Robbins and Heikkinen (2006: 6) affirm: 'Discourses, expert communities, and technologies of measurement are as much a part of political ecology as systems of production, land rights, and resource use'.

Introducing a disease detection technology

The ability to *detect* infection is crucial if diseases are to be revealed and then eradicated. The skin test is the technology at the heart of the TB eradication programme in NI, and has been since its inception in 1959. Tuberculin has a much longer history, and has been widely used to diagnose TB around the world since the late nineteenth century. Danish vet Bernard Bang was experimenting with tuberculin as a diagnostic tool on a herd of cattle by authorization of his Government as early as 1892 (Bang, 1908). The tuberculin test was popularized in

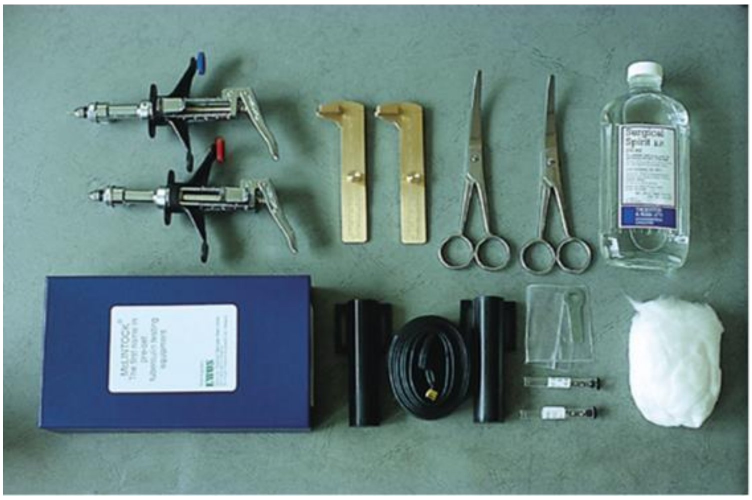
Britain by vet John McFadyean, who had published his initial observations on the test in 1891 (Glover, 1937).

Tuberculin (Fig. 5) is a purified protein derivative produced in two forms from the bacteria *Mycobacterium avium* (avian TB) and *Mycobacterium bovis* (bovine TB), which, when injected into the skin of an animal, provokes an immune response in those which have previously encountered the bacterium. Stringent regulations govern the production of tuberculin according to internationally-agreed standards to ensure its consistent potency (Monaghan *et al.*, 1994). But like anything else, tuberculin must be used with caution and due care: 'While tuberculin is a most reliable diagnostic agent when properly used, it may lead to erroneous conclusions when improperly applied' (Moore, 1905: 14).

Figure 5: Fifty-dose bottles of avian (red) and bovine (clear) tuberculin (Source: DARD)

The conduct of the test by vets must be according to standard operating procedures (DARD documents known as 'VP1' and 'VP2') written and enforced by the state. All vets in NI use the same essential equipment to conduct the test (Fig. 6), and all cattle herds in NI are tested at least annually, but more frequently if a herd becomes infected with TB.

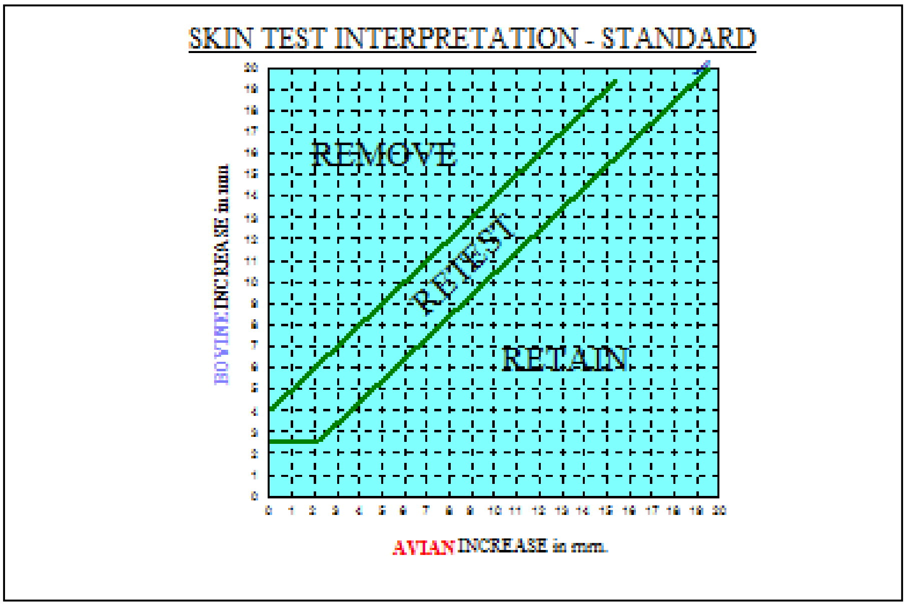
Figure 6: TB testing equipment (Source: DARD)



The vast majority (more than 90%) of TB testing in NI is conducted by private vets acting as sub-contractors for the state (similar proportion in GB), and income received from testing can often make up a substantial percentage of farm practice turnover. In the ten-year period from 1996/97 to 2005/06, £54M was paid by the state to private vets in NI for TB testing (NIAO, 2009).

A number of state vets (known as Veterinary Officers Testing – 'VOTs') are employed to test full-time, and they focus more on reactor herd tests where infection has previously been revealed. Other state veterinary officers (VOs) mostly re-test inconclusive animals and animals which have been forward-traced from reactor herds. All vets (private and state) are subject to random inspections of their testing skills by state veterinary inspectors in an effort to ensure that the test is conducted according to the state requirements. The interpretations of skin measurements in the field must be according to predefined standards (Fig. 7), metrics of skin calculations creating a 'nicely simplified black box that might be carried anywhere' (Law, 1986: 252).

Figure 7: Chart for SICCT test interpretation of skin measurements at 72 hrs (Source: DARD)



The grid allows the 'laboratory' and its 'scientists' to move onto farms (Latour, 1988). Like Law's (1986) Portuguese sailors with their tables of declination on far-distant seas, the same rules apply, wherever a vet may be checking the interpretation chart. The chart therefore provides something 'scientific' of which Alexander von Humboldt would surely have approved: 'A grid of data, disembodied from their local materiality and processed in linear and graphic representations, sundered from the historical vicissitudes of their production' (Bourget *et al.*, 2002: 16). Supervisions of vets testing on farms by the state are a way of trying to ensure that 'the periphery must respond … to the behest of [the] centre' (Law, 1986: 241) in a different form of long-distance control and extraction of compliance, designed to enforce the written rules or inscriptions of the state. The key to success for the state is the right combination of 'documents, devices and drilled people' (Law, 1986: 254), but down on the farm there is still more heterogeneity than they might wish for or expect. The envoys are certainly 'mobile, durable, forceful and able to return' (Law, 1986: 257), but long-distance control of the TB test is often an uncertain affair.

A testing narrative

Deployed in the hands of skilled veterinary experts, tuberculin, McLintock syringes, scissors, calipers and the interpretation chart make up the technologies of testing for TB. The state operates through its veterinary subcontractors at the scale of the farm yard; prescribed practices have been agreed, and common scientific standards have been established to produce the numbers which make knowing TB possible. But creating scientific uniformity and homogenization poses a challenge given the contingencies and indeterminacies of relations between human and non-human, both material and social, down on the farm.

To enliven the challenge involved in the performance of this technology I will now change tack and tone and use a fictional literary narrative to illustrate how a private vet might experience a TB herd test. The series of events are drawn from hundreds of tests conducted during my veterinary career, and they are typical happenings and emotions, brought together in a narrative of a routine Annual Herd Test in the depths of winter. In keeping with the performative nature of the test itself, this narrative aims to open up and embody the subject, acting as a 'performative intervention' (Gregson, 2011: 140) to bring technology to life. This introduces the human (vets and farmers) and non-human actors (bovines), and also some of the liquid materiality involved with TB testing: rain, water, disinfectant, surgical spirits, cow dung, urine, saliva and tuberculin. Testing is a messy performance, and this narrative illustrates its corporeality.

On a dairy and beef farm, somewhere in NI, in mid-December

'I was late for the test. I hated being late, but circumstances worked against me that morning. I had called into the surgery to collect the test sheets and the tuberculin and got caught with having to treat a sick calf before making my departure. Job done, I jumped into the car and set off at speed to make up lost time. I nearly lost control on the slippery bend in the road near the farm. It was tipping down and as I pulled the car into the farmyard it only seemed to get worse. It was going to be one of those days when the wet and the cold penetrated every layer of protective clothing and chilled to the bone.

The farmer came round the corner, greeted me with a grunt, and asked what had kept me. The practice manager had arranged the test for 8.30 am, and by now it was nearly 9.15 am. By the bellows emanating from the sheds, the cattle – all 353 of them - were waiting and perhaps peeved too. Cattle never enjoy testing - chewing the cud was more fun.

I asked where the nearest water tap was. He nodded towards the milking parlour and walked off. I filled up the bucket, poured in the disinfectant and doused my boots and waterproof trousers in the pungent brown liquid. I placed the bucket conspicuously beside my car boot just in case DARD inspectors turned up unannounced to assess my testing performance – you never knew the day, and it was often when least expected it – even on wet days.

The (supposedly) waterproof coat was donned, and the pockets filled up - scissors, calipers, bottles of tuberculin, pencil … had I got everything? Oh, almost forgot the test sheets. I hooked the syringe holder belt around my waist, and cleaned the McLintock syringe needles with surgical spirits. I filled up the syringes with avian and bovine tuberculin, 20 doses to each syringe, taking care to expel air bubbles after each draw. Bubbles caused the syringes to misfire and deliver an incorrect dose of tuberculin: bubbles were best avoided. I stuck a woolly hat on my head and set off for the cattle crush.

I had been here the previous year, and it hadn’t been a pleasant experience. Everything had gone well to begin with, and the farmer had seemed pretty friendly, but as soon as I found a reactor just after lunch, all changed. It was on the borderline between being a reactor and an inconclusive – there was only a millimetre in it and I could have squeezed the oedematous swelling a bit harder perhaps, but I thought I better do the right thing and declare it as it was – a reactor. The easier option would have been to make it inconclusive and give it another chance – if it came up positive again, at least it would be the state VO taking the flak at the retest. Mr Smith had become very angry on news of the reactor. He said I obviously hadn't measured it correctly, and since there was only one of them, it must have been my mistake. As a newcomer to the practice and to my career as a farm vet it was rather a shock to my tender constitution. No TB lesions were found a few weeks later after the cow had been slaughtered, which made him all the angrier at the time. I tried to avoid coming back this year, but the boss had insisted – there was no one else to do it.

The cattle crush – a restraint pen with a race to channel the cattle in a long line towards the front gate – was outdoors, and I noticed the rain more than ever as it came into view. A line of a dozen cows were waiting for me. These were part of the dairy herd and they went first, before the rodeo began with his pedigree Limousins – some kind of arm injury was a distinct possibility later in the day. Last year one of them catapulted from the race into the collecting pen in a fit of pique, narrowly missing Mr Smith's head in the process. Mr Smith assured me his cattle were usually good-tempered; vets in waterproofs and armed with McLintock syringes appeared to provoke an allergic reaction.

I went up to the first Holstein cow in the race. I grabbed her right ear and checked her yellow plastic ear tag number. Dung covered half of it and I couldn't make the number out. The other tag on the left ear was no better. I spat on the cup of my hand and rubbed the muck from the tag with my spittle mixed with the rain. It worked well - 4513-9 … I checked her number against my test sheets, and there she was on page 15. I marked a tiny cross in the margin of the sheet.

I clipped two marks a handbreadth apart in the mid-region of her neck. The bottom mark – the bovine site, had to be slightly in front of the top mark – the avian site. She was a pedigree Holstein, and her hair was very short. She jumped as the scissors nipped her skin rather than trimming the hair. She tried to back off at speed, but had nowhere to go. I pinched the skin at each mark and measured the thickness with my calipers – 7 mm and 6 mm. I pulled out my McLintock syringes one at a time, starting with the red-marked avian, and made the injections into the skin, avian on the top. After each injection I had to feel for a 'pea' – a bleb in the skin to confirm the injection was where it should have been. State vets always made a big thing about feeling for the pea, but I just knew by the feel of the syringe barrel's resistance against the palm of my hand whether it had hit the right target. If not, it spewed and dripped pathetically from the scissor mark, and if the needles were too long, the injection would go under the skin rather than into it. Not this time - all had gone well, and I wrote the skin readings against her ear tag … 1 down, 352 to go. The sheets were going to get wet and I feared them turning into paper maché before the day was out. My precious numbers could disappear into the fibrous soup. I desperately needed them for the second day of the test when I came back to measure the reactions in the skin.

The third cow had watched her two comrades being pricked and prodded and intelligently thought it was best avoided. As I aimed for her ear tag she drove forward and rammed her head firmly under the cow in front. She got urinated on as we tried to poke her nose back, but this made her more of the opinion she was best to stay where she was: Holsteins could be ever-so-determined when they wanted to be. As I reached over the rail of the crush to take a different angle of approach to the ear one of my syringes tumbled out of its holster and landed in the fresh pile of dung just under her nose. The day was going from bad to worse. I retrieved it at some risk to the integrity of my arm and found the needle was bent – I would have to go back to the car to replace it and wash the syringe under the tap – more time wasted, and an accusation of ‘a dirty needle’ could be forthcoming if the test produced a reactor.

I muttered apologies as I trudged off. I didn’t stop to hear a reply, if there was one. I’d only tested two cows, and with 351 to go, including my determined Holstein opponent, I had one of those moments where I wondered why I’d gone to vet college for five years. My fingers were freezing cold, and the drips of rain ran from the end of my nose … maybe I should have worn thicker socks? It was shaping up to be a hard day, and we hadn’t even started the Limousins. If I finished the dairy herd by 3 pm I’d be doing well at this rate. I would have to speed up, because a good test is a fast test – both for me and for the farmer, especially on a day like this. It gets dark early in December. Then there was the evening small animal surgery starting at 5.30 pm. That would give me time to thaw out before I headed home for a quick dinner with night calls to follow.

At least 353 animals were earning a tidy sum for the practice, if only I’d seen the half of it. I just hoped that the test was going to be clear this time. I’d never even had the chance during the year to earn credibility points with a successful calving or a calf pulled back from the brink of death from pneumonia. The boss told me once that he had lost clients after reactor tests – it was easy for farmers to switch practices, and we couldn’t afford to lose the business. But such thoughts are irrelevant, of course – I am a servant of the state playing my part in the eradication of TB. I am only doing my duty, whatever the result in three days’ time.’

Narrative complete, we now return to what Gregson (2011: 148) calls the ‘academic register’. This narrative has illustrated a number of salient features of TB testing which will be examined further in the remainder of this chapter. Firstly, TB testing technology uses the measurement of skin thicknesses to produce numbers to know whether an animal is infected with TB. In this regard it is a science that produces a numerical knowledge which makes the disease both 'legible' (Scott, 1998: 25) and able to be circulated, thereby allowing the state to standardize and govern it. Secondly, the TB test is not just a science through metrology, but like many other tests in other spheres, it is a 'performance' (Pinch, 1993) which has many witnesses. It is regulated by the state, which in turn is also regulated, and the test is conducted under the watchful (and often disapproving) observance of farmers. Thirdly, it is a scientific technology which has largely lost the trust and confidence of the farming population, and even the vets who perform the test yearn for better alternative technologies. Finally, it is a fluid and indeterminate assemblage of the human and the non-human; the material, the social, and the political. At each of these points there are cracks, controversies and confusions, making TB testing not just a messy, but also a contested and conflicted business.

Science - metrologies through technology

As already outlined, tuberculin is the reagent which produces the reactions of the TB test. It is a useful and oft-used substance, with hundreds of thousands of doses being used in NI annually in TB tests. McFadyean remarked that 'without tuberculin even the sharpest and most experienced [veterinary] practitioner is powerless to detect tuberculosis in its early stages' (Glover, 1937). With cattle very rarely developing the visible clinical signs of TB on farms in the 21st century, the swellings in the skin form the basis of TB detection in the field. In measuring the size of these swellings, vets create numerical data and the scientific *metrologies* of TB. Atkins (2007: 974) notes the importance of 'knowing the world through classification and measurement'. Mallard (1998: 571) goes further and states that 'measurement - the quantification of natural phenomena and their translation into numerical forms … is the hallmark of modern science'.

However, controversy surrounding the efficacy of the tuberculin test, the chief diagnostic tool for TB, means that the metrology of the disease is often contested. Rather than ‘technologies of trust’ (Atkins, 2007: 976) there are technologies of *doubt*, and these uncertainties have been present for as long as tuberculin has been used as a diagnostic tool (Waddington, 2004). The perceived unreliability of the test by farmers and vets reduces the scientific authenticity of the diagnostic procedure, creating overflows and leaks in the system. Callon (1998: 255-261) suggests that overflow situations and ‘hot situations’ can be framed and dealt with, but points out that reliable measuring devices are required. This is not entirely the case for TB, and the fluidity of diagnostic measurement adds to the complexity of the problem by increasing scepticism that TB can be eradicated by a continuation of the current method of repeated testing, removal and slaughter.

This has been demonstrated in previous research on the geographies of TB testing. Enticott (2012a), conducting ethnographic work on English and Welsh farms, has shown that the tuberculin test is controversial, mistrusted and disliked by farmers and sometimes by vets as well. Enticott (2012a: 83) reports that for vets: ‘When judging the results, it is not simply what the test tells them that is important, but a complex entanglement of relations taking in the history of disease on the farm, the type of cattle, their locations, and the social characteristics of the farmer,’ meaning that ‘results can be changed.’ Enticott (2012b) also found that male vets had significantly higher reactor detection rates than female vets, and that state vets were more than twice as likely as private vets to diagnose infected herds (Enticott, 2014). The numbers produced by the test seemed therefore to be fluid and open to varying interpretations depending on the epidemiological history of disease and empathy towards the socio-economic predicaments or personality of the farmer (Enticott, 2012a; 2012b; 2014).

In my study farmers often volunteered, and some vets as well, that the test was 'not 100%' or 'not accurate' as part of their explanation of why TB continued to be a problem in NI. Suggesting reasons for the failure to eradicate TB, one private vet said that the TB test was 'less than perfect … not the people doing it, but the test itself' (Int A39, private vet). There was an expectation of precise and objective repeatability from farmers. The vet cited above seemed to suggest that vets could be perfect, but the test came up short. In as far as aspiration was concerned, metrology was therefore to be black and white, but the reality was vague shades of grey. If metrology was a form of 'purification' to expunge impurities (Dörries, 2001), the desire for 100% accuracy aimed for a *pure* and uncorrupted measurement of TB. Whilst it can be argued that precision and accuracy are distinct, taking the historical position of the science and instruments of measurement they become interchangeable and: 'Precision is everything that ambiguity, uncertainty, messiness, and unreliability are not' (Wise, 1995: 3). The aspiration for accurate measurement may be a feature of Victorian Britain (Schaffer, 1995) which has lasted through to the present hope for 'perfection' in TB testing, and there was frustration with the progress of scientific endeavour if the tuberculin test was the best that could be offered.

Vets suggested that farmers needed to be more realistic about the failings of the test and to accept that it was the best available. As already mentioned, they were keen to emphasize the failings of the science and technology rather than the one who *implemented* the technology:

> 'But the ones that go down with lesions at slaughter after being recently tested clear … yes, it undermines their faith in the test, but maybe it helps them understand that the test is not perfect – that's life. It also helps them to understand that it is not the people who are doing the test who are at fault - that there are limitations to the test.' (Int A48, private vet)
>
> Vet 2: 'It's hard to detect all the carriers - you're trying to identify diseased animals - you can get most of them but getting all of them is really difficult.'

> PR: ‘So what you think about the skin test?’
>
> Vet 1: ‘It's a lot less than perfect, is my understanding of it, but it's the best test we have.’ (Int A39, private vets)

Vets largely accepted the TB test in the light of few feasible alternatives for mass surveillance of the cattle population in the field. But not everyone was dissatisfied with the accuracy of the test. One farmer, taking a more positive outlook on the test, suggested that no biological test could be 100% accurate (Int A22, dairy farmer). Several farmers thought that the test *was* accurate, based on the evidence that reactors had been identified in their herd with confirmation at slaughter:

> PR: ‘What do you think of the skin test that vets perform on cattle?’
>
> ‘Well, for us it seemed very accurate - it picked out one cow, and it had TB. We have had cull cows, and as yet we have never had anything turn up in the abattoir, but the one that showed up on the skin test when they took it away had TB - it seemed very accurate.’ (Int A37, dairy farmer)

As vets were keen to emphasize, the test has innate failings irrespective of the veterinary performance of the test in the field, and there are several well-recognised *scientific* reasons for false-negative animals which I have labelled *ecologies of evasion*. One such, the phenomenon known as latency (Pollock & Neill 2002), is another example of nature ‘striking back’ (Latour, 2000). Latency occurs when the TB bacteria in an infected animal become encapsulated and ‘hidden’ from the animal’s own immune system, and no reaction is produced in response to the injection of tuberculin. This period of inactivity without progression to disease is also considered an important feature of human tuberculosis (Lin & Flynn, 2010). In such a state, the TB bacteria appear content to bide their time before exerting their destructive effects, waiting for an opportune moment to reactivate when defences are weakened through advanced age or a compromised immune system. As vets pointed out, detection efforts in these cases could be foiled from within:

> 'There's more and more evidence showing that the TB test is only a diagnostic window - if you miss that - if somebody allows a small lump through in its previous life and then it passes a number of tests and goes off. Probably most of them don't go off and we miss them in the abattoir and it's of no significance, but every now and then you will have a little pop - a little explosion of disease up there - she might take a herd or a neighbour down with her …' (Int A56, state vet)

Throughout this 'in-between' state of latency, something like humans in remission from cancer, the infected animal is 'neither sick nor cured' and in 'a space that has no concrete conceptual boundaries' (Stoller 2012: 177), existing between the 'normal and the pathological' (Canguilhem, 1978). In this indeterminate state, TB hides from revelation.

Anergy is another scientific phenomenon that creates false negatives, and arises under certain circumstances in advanced states of TB (Pollock & Neill, 2002). Even though there are high levels circulating antibody, the animal does not produce a cell-mediated reaction to the tuberculin. Animals in the early stages of infection will not react either. Other animals have an in-built genetic predisposition to pass the tuberculin test, especially those carrying the '22' genotype (Amos *et al.*, 2013). To make matters worse, there are evidences of synergies between *M. bovis* and other biological species which weaken the efficacy of the test. Experimental evidence has suggested that the parasite *Fasciola hepatica* (liver fluke) weakens immune responses (Flynn *et al.*, 2009; Claridge *et al.*, 2012), allowing TB to further evade detection. Similarly, co-infection with BVDV is thought to compromise diagnostic tests, and the immunosuppressive effects may potentiate susceptibility and onward transmission of infection (Monies, 2000; Kao *et al.,* 2007). These ecologies of evasion handicap vets' diagnostic capabilities before tuberculin even enters the skin.

The chief complaint from farmers concerning the accuracy of the test was the tendency to miss infected animals, falsely declaring them as negative, and leaving a ‘hidden burden’ of infection (Conlan *et al.*, 2012). Problematically, whatever the reason, the technology fails, and such unreliable results weaken faith in the authenticity of the test’s metrologies:

> ‘I have seen us testing and getting clear in the test and having three cattle ... we tested on a Monday and Tuesday and then Thursday and Friday, and killed the following week on the Monday, Tuesday and Wednesday, and there was one animal down with TB each day ... I'm not being cheeky - it makes you laugh. It is funny. You get word you have an animal down with TB the week after you test, and you think “All that bother - why did we do it?”’ (Int A7, beef farmer)

In addition to the science of nature striking back, Enticott’s work (2012a; 2012b; 2014) has shown failings in the metrology on the farm linked to vets. A failure to correctly identify truly infected animals may suggest that the test was improperly conducted by the vet, either through not injecting the animal with the correct dose of tuberculin, or by not measuring the reaction correctly. There may be socially-embedded reasons for some of these failings in the technology. State vets accused private vets of being influenced by farming clients to avoid declaring animals as reactors or to fail to conduct the test as required by the rules. This was said to potentially account for a difference in reactor detection rates between state and private vets, and was also linked to beliefs about the reality of the disease that we considered in the previous chapter:

> ‘Is it that the DARD [state] vet is erring on the side of taking the animal out, and the PVP [private vet] is erring on the side of leaving the animal in as an inconclusive? That could certainly create a difference.’ (Int A55, state vet)

> ‘The farmer may not want a breakdown, and may see himself as being financially ruined, human nature being what it is, is it a surprise that we do not get all the breakdowns we should; and that calipers are squeezed; and that we hear stories of people not turning up on the second day; because the vets are so ... they are financially driven, and if they don't see the disease as a real disease, and a disease that they can eradicate ...’ (Int A42, state vet)

> ‘There's also the pressure - they [farmers] are clients and they don't want to leave them in a situation where they can't sell, and they don't want to leave them with a lot of extra animals and they will obviously have money

> problems, so they don't want to be that bad person - they want us to be that bad person.' (Int A43, state vet)

No private vet admitted to being influenced by farmers to change the results of the test or to take shortcuts in testing, but some admitted they had lost farmer clients as a result of positive tests. One young vet accepted he felt a pressure to conform to the wishes of some farmers; a pressure that he had to resist:

> PR: 'How much pressure do you feel under from farmers as young vets? You're standing there, and he's saying, "You know, I'm going to export next week, or tomorrow", and you've got a borderline IC, or a borderline reactor. Do you feel the pressure?'
>
> 'You would feel the pressure a bit, but you know that if you don't stand up now, those boys will always be at you, and you just have to be strong and say "Look, this is it". You know that if any of those guys take hold of you now they'll always have it on you, they'll always be at you to do it again, and again, and then where does it stop? You are under pressure, but you just have to stand up - it is hard at the time.' (Int A59, private vet)

Unconfirmed reactors to the test also decrease farmer confidence in the expertise of the vet and the diagnostic process. While these animals react positively to the tuberculin, they may be due to cross-reactions with other environmental bacteria and not TB (i.e. false positives); or the animals may be truly infected, but the lesions are too small to be found in the carcase after slaughter. If lesions are not found, it is also unlikely that bacteriological culture will find TB in the follow-up laboratory investigation of relevant tissue samples. Whatever the scenario, farmers struggle to believe that 'No Visible Lesion' (NVL) animals truly have the infection, despite the skin measurements. If van Dijk (2013) is correct in his assertion that there are in reality many more healthy false positives than are generally acknowledged, then farmers have reason for such scepticism.

This drawback was recognised long ago by McFadyean: 'It is evident that the proportion of cases in which non-tuberculous animals react does not require to be large in order to deprive the agent of its whole diagnostic value' (Glover, 1937: 369). Monaghan *et al.* (1994) make a similar point, believing it to affect both farmers and vets: ‘Consistently high “no visible lesion” results will diminish confidence in the test, lead to more liberal interpretation of test results [by vets] and greatly increase the level of farmer antagonism towards the eradication effort’. As one practitioner lamented:

> ‘For us as vets on the coal-face identifying reactors, it's very annoying for us to go out and give a man say five reactors and then the report comes back and it says “No Visible Lesions” on five animals; and the farmer next time you're out says “Aye, what do you know? You were wrong - those animals didn't have TB”’ (Int A40, private vet)

This vet felt that the state’s terminology of ‘NVL’ greatly undermined the test result and was ‘a PR disaster’; others agreed.

The metrologies of the TB test certainly have their failings, and these have to be coped with. As King (1952: 140) mused on whether medicine is an exact science, he replied: ‘To a certain extent yes, to a certain extent no ... Does medicine have the same degree of predictive accuracy as physics? Obviously, no. But whoever claimed that it did or should?’ When the TB test has a sensitivity (ability to detect positives) of somewhere between 52% and 100% (de la Rua-Domenech *et al.*, 2006), not everything can be blamed on vets’ potential tendencies towards subjectivity in interpretation of the swellings in the neck – life is often more fluid and messy than that (Law, 2004). Perhaps therefore the success of TB metrologies in correctly identifying hundreds of truly infected and lesioned animals is the blending of both science and artistry (Hamilton, 2012); or science mixed with performance in the field.

Performance of technology

TB testing is not just about the science of metrology - it is also a performance. Performance is something to do; a practice; an activity (Szerszynski *et al.*, 2003). Testing is an art, a skill to be learned, improved and practised. Even though very different from the typical work of veterinary diagnosis, TB testing is a feat of manual dexterity and cattle handling ability, adapted to the surroundings encountered on each farm and with each animal presented in the crush. In accordance with the views of Szerszynski *et al.* (2003: 3), performance is ‘ephemeral, unpredictable, improvisatory, always contingent on its context’, and is therefore a situated affair, very much depending on the stage provided on the farm; some tests are easier to conduct than others. As seen in our testing narrative, there is always a place for the unexpected. According to the vets interviewed, an enjoyable test was one with good facilities, plenty of help, good conversation and co-operative cattle. The audience for the performance therefore incorporates both the human and the animal.

One young vet thought that he had become ‘slicker’ in his testing ability and it was becoming easier (Int A59, private vet), and another ‘had no real difficulties in performing the test as such’ (Int A17, private vet), apart from testing fractious animals. Farmers needed to be brought into line as well as animals, and vets used script lines to initiate proceedings as the test got under way:

> ‘I would generally ... like everything else, it maybe depends on how you approach it. Generally before the test starts on the first day, I would say “I hope we have a clear test.” And then I would generally say “This area is not too bad”, or “This area is quite bad”, and so on. You never know ... You generally would try and at least mention the fact that they don't all go right before you start.’ (Int A51, private vet)

> ‘Also, I will say to them if they say “Oh, I hope I get a clear test” and I say “... At the same time I don't want to leave you with any TB in your herd, so if there's any TB in there we need to find it.” So there's never really been any antipathy towards me with getting reactors - I can still go back to the same farm next year and they'll be really friendly and they feed me.’ (Int A43, state vet)

Vets were proud of their skill in handling animals, coping with testing facilities, making conversation with farmers, and working at speed. Farmers especially admired particular vets who could process animals efficiently and perform the test in record time:

> 'He's the best man for testing who has ever set foot in this yard, and he does all his own clerking [recording skin measurements].'
>
> PR: 'Why's he so good?'
>
> 'He just knows how to handle cattle. He slips about his business quietly, and I think he must have a photographic memory as well, because he does his own clerking. The second day he did 852 cattle in the morning, and he read every single one of them. He's absolutely brilliant at it.' (Int A38, beef farmer)
>
> 'Oh yes, they would be pretty fussy. Actually the last three tests were done here by a Ministry vet ... she was as efficient a lady as I have ever seen at doing her job well and quick, and no messing, but very strict to what she was doing ... she would have been the quickest vet ever I have seen testing ... On the cows she just made two nicks with a twist of her hand and you would have seen the two marks like daylight and dark, and [*laughs*] it speeded up the show.' (Int A35, dairy farmer)

Performance, in addition to being situated, was also in the eyes of the beholder. Most farmers were very content with the performance of the test on their farm, and they believed that vets were very thorough and did the job to the best of their ability. A few complained about state vets and described them as being 'too fussy' and overly eager to find reactors. Such vets were accused of measuring swellings that could not be seen: 'seeing' TB is important for belief in metrology and performance. Having measured the swellings and found a reactor, vets spoke of how they broke the bad news to the farmer and encouraged him to see for himself using performative lines to smooth the way:

> PR: 'How do you break that news to them? You have your calipers and you're measuring and it's the first one that goes down - what do you say?'
>
> 'Oh, maybe they are not just there on the spot, maybe they are filling the crush, and I always say "Look boys, we have a problem here", and I always get them to come and look at it and show them the difference in the skin, and show them the visible lump, and show them that the animal is down, rather than letting the animal out and saying later on "You had two animals down". I always show them the animal, and show them the lesion on the animal.' (Int A17, private vet)

A state vet felt 'lucky' (Int A43) that all of the local private practitioners used calipers rather than merely a visual inspection for swellings, and so she did not look out of place in following the rules of the DARD testing contract. The farmers in the focus group felt that vets could sharpen their performance of the test to find more reactors, suggesting they were overly hasty at times:

> 1: 'We're not implying that vets are going out and putting an animal down to keep themselves testing //'
>
> 2: 'No, not at all //'
>
> 3: 'Definitely not.'
>
> 1: 'But they could tighten up drastically //'
>
> 2: 'I know that sometimes private vets can be too quick to run animals through a crush or whatever //'
>
> PR: 'A lot of people like that //'
>
> 2: 'Of course you do, if you're a farmer and you get it done in two hours you love it, rather than four hours.' (Int A58, farmer focus group)

Similarly, another farmer thought the delayed detection of TB in his herd had been due to a vet 'not checking properly' (Int A29, dairy farmer), which had made his TB outbreak worse in the long term. Some state vets were quick to criticise the performance of the test by their peers in the private sector:

> 'Standards of testing among vets are a bit embarrassing actually, and as a profession we haven't actually stepped up to the mark and done a really good job on this disease - that is becoming more and more apparent the more we look at the figures.' (Int A42, state vet)

Aside from accusations of deliberately failing to declare reactors or carelessness, one vet suggested those testing beyond retirement age were physically unfit to test properly. When asked about testing performance, virtually all of the private vets interviewed strongly denied that their testing was of an unacceptable standard. In defending themselves, one practitioner compared vets' performances to counterparts in Scotland, and later in the interview widened his comparison to continental Europe, suggesting that the failure to eradicate TB was not due to poor testing in NI - recipes for TB success lay elsewhere:

> 'Now, I would argue that the quality of TB testing done by veterinary surgeons in Scotland, for example, is no different to the quality of testing

> done by vets in NI. And having seen testing done in Scotland, I know that for a fact. But they managed to get rid of TB. So you need to be looking for things that are different. What is different here from Scotland? So to say 'We must test better or we won't get rid of it.' There's a degree of truth in that, but it's not the whole answer.' (Int A46, private vet)

> 'I don't think German vets or Italian vets or French vets are any better at TB testing than we are. It has to be something else.' (Int A46, private vet)

Only one private practitioner admitted to becoming careless through the boredom of repetitive routine, and he seemed uncomfortable about making the confession:

> 'Vets are very blasé about it, and they go "Yeah, yeah, yeah ... here's a lump." After your 500th animal you get very ... you get very careless, you know? [*clears throat*].' (Int A19, private vet)

Another suggested past failings in testing performance by vets, but a marked improvement in recent years, mainly due to more state supervision of testing and a new generation of vets *expecting* to find TB reactors rather than being surprised by TB's presence:

> 'For the first 10 years I was in practice, I tested something like ... 25,000 cattle a year ... And there was no TB detected, there were no reactors, apart from animals that were imported from the south of Ireland. There was no indigenous TB whatsoever ... there was genuinely no TB, and it did breed in a sort of relaxed attitude to TB testing, and since the rise of TB from the early 1990s onwards, that has really been the change. So young vets are coming in expecting to see TB reactors, and I think they do it better.' (Int A48, private vet)

So it seems that attitudes affect performance in addition to field situations. When vets in the past did not expect to reveal the hidden presence of TB, they relaxed their performance. Now that presence was nearly ubiquitous, performances had improved, but not as much as state vets may have liked, and not across the board:

> 'Unfortunately statistically it would look like the gap between Department testing officers and private practitioners is widening, and it shouldn't be, and that worries me - it worries me greatly. But how much of that is due to outright fraud or lack of confidence in the test - I think a lot of it is due to lack of confidence in the test, and therefore the test is possibly not being done exactly as it should be.' (Int A41, state vet)

While the state's TB test instructions require veterinary clinical examination as part of the diagnosis, this is rarely done in practice – there is usually nothing to see or feel. Vets are basically impotent without the tuberculin test, and this powerlessness renders clinical expertise redundant: the disease defies the normal seeing and knowing of the 'clinical gaze' (Foucault, 1997: 108) or what Hamilton (2007) calls the 'veterinary gaze'. It also surely affects the vet's professional pride in knowing more than the farmer: 'Their … ability to see more and further than their farm clients, treating the sharpness of their senses as a form of professional know-how that they attribute to their superior training and insight' (Hamilton, 2007: 490). When speaking of diagnostic technologies, Canguilhem (1978: 134) affirmed that: 'A microscope, a thermometer, a culture medium know no medicine … They give a result. This result has no diagnostic value in itself. In order to reach a diagnosis the sick person's behaviour must be observed'. But with TB the result of the measurement is everything – the caliper readings become the diagnosis, and the performance of clinical diagnosis is rendered largely impotent. There is no behaviour to observe, for the infection is hidden in the depths of the bovine body, and even the tuberculous cough of yesteryear is rarely heard today. Unlike the anesthetists who can disbelieve the numbers produced by their monitoring technology to fall back on clinical skills and assessment (Smith *et al.*, 2003), vets cannot 'see' TB, and as Enticott (2012b) showed, they may try to reason away an unwelcome or unexpected caliper measurement.

Perhaps therefore the problem with TB metrology is the reduction of the disease to numbers, numbers which both farmers and vets may struggle to believe in. With questions over sensitivity and specificity of the test, and with the embodied skills of the vet reduced to measuring swellings in the skin on the surface of an animal's neck, TB becomes a diagnostic disease imaginary unlike any other on the farm. Farmers struggle to express what they think about it:

> 'Oh, I don't know. I know nothing about that end of it really. You would imagine it is a dicey thing when you're depending on swellings. If there

> were other infections or things ... I just don't know ...' (Int A11, dairy farmer)

'Depending on swellings', the test is arguably the essence of fluidity and subjectivity, matching the malleable decision-making that may go along with it:

> 'You are dealing with a test that does not have an objective readout - it's not as if someone gives you a titre and says there you go - there's an element of squeezing calipers, of judging yourself how big the lump is, whether there is oedema. In fact, even worse, the animal might not even be in [a crush] and be subject to calipers - someone may be standing a couple of metres away saying "Oh, I think that's all right."' (Int A42, state vet)

Instead of the earthy description that Hamilton (2007: 490) provides of clinical veterinary diagnosis as 'assessments from what can often appear to be a bewildering array of smells, sights and sounds ... smelling the cow's breath, feeling around the mouth, squirting some milk from a teat, smelling or feeling the texture of excreta, squeezing, flicking, listening to and palpating the cow's body ...', there is only a swelling to be measured, and a chart to be checked; mere numbers replacing diagnostic materiality. Unlike FMD, the measurements of the 'laboratory' have to supplant the lived experiences and earthiness of the 'clinic' for the vet to create TB realities (Law & Mol, 2011). As Büscher *et al.* (2010: 4) describe, there is a 'tension between *embodied* diagnosis ... and *mediated* diagnosis (in which information may be given numerical values ...).' In such a scenario, vets struggle to know whether they were objective scientists following coded procedures, or artisans adapting to messy conditions to form risk judgements:

> PR: 'Is performing the skin test as a vet a scientific procedure?'
>
> [*4 second pause*]. 'I think so ... yes, it is.' (Int A10, private vet)
>
> 'The blood test ... would be very much better than relying on a skin test which relies unfortunately on human beings testing, which is fine if there's a good set-up, but in a bad set-up ... even I would admit that I haven't always done it 100% right.' (Int A47, state vet)

Attitudes to the uncertain metrologies of TB appear to have affected the performance of technology. Could it be that this root of metrological uncertainty has a seminal influence producing variations on the prescribed performance, weakening the resolve of the actors in their ability and determination to find reactors? Or does poor performance increase the fluidity of the margins of metrological precision? Perhaps a blend of both is closer to the truth. According to one state vet, for private vets the test is no longer a diagnostic process - just an object - and perhaps with it came ontological insecurity as to what TB diagnosis actually is: 'Applying the skin test, they do not think of that as a diagnostic test - it's just a thing' (Int A56, state vet). If testing is just a *thing*, perhaps Bennett (2010: 63) is correct in praising materialists Bergson and Driesch for suggesting that the *matter* of nature 'was not in principle calculable: something always escaped quantification, prediction, and control'. There will always be leaks and overflows when dealing with the matter of techno-biological systems, no matter the level of performance.

Losing faith in the technologies of testing

As earlier described, there is widespread dissatisfaction with especially the metrologies, but also the performances of the TB test. Alongside this dissatisfaction was a yearning for something better; something more accurate; something easier to perform; and something which was more objective to detect and measure TB:

> 'Well, they've just got to keep on trying to get on top of it, but at the end of the day we need a better test, I think.'
>
> PR: 'That would be your number one priority - get a better test?'
>
> 'A better test - a definitive test - but they don't seem to be able to do it.' (Int A28, dairy farmer)

This yearning was particularly marked amongst farmers, but also several private vets shared such opinions. State vets tended to have higher opinions of the scientific capabilities of the TB test, if only it was performed better, and a more resigned acceptance that it was the best available detection tool:

> 'I like the test to be honest - I think it's pretty good, but once again with farmers there would be a certain number of animals missed, or a certain number of reactors missed, or a certain number of false positives - and they don't like that, they want it [to be] black and white.' (Int A47, state vet)

Rather than slowing down the progress of technology (Bingham, 2008; Macnaghten & Chilvers, 2014), both farmers and vets were very keen to see the process speeded up with respect to developing TB technologies. There was frustration that the SICCT test was still being used, when everything else in life appeared to have moved on to newer and better:

> 'The test is not good. I proved it - there were 3 animals out of 70 [confirmed as TB] ... 72 was it? So I am extremely sceptical about the test and in this day and age of DNA and whatever, they are using a test which was being used in this yard 50 years ago.' (Int A32, dairy farmer)

> '[The] test isn't fantastic, but I suppose it's all there is. But why is it that that is all there is? How long can the farmer believe, or us for that matter, that we can't get *something* to test them ... Surely the technology ... every year we are getting something new, and some reasonably decent advance in things - it's wonderful some of the advances we are having ...' (Int A19, private vet)

> PR: 'So what changed?'

> 'I don't know. I don't know. The method for carrying out the test hasn't changed – it's the same syringes, it's the same tuberculin, the same old stuff, and for years before I tested.' (Int A51, private vet)

> 'It seems a very antiquated way of diagnosing disease - clipping the neck and injecting at two sites.' (Int A46, private vet)

Farmers strongly advocated scientific and technological progress in disease control. For example, they mentioned how vaccines and better medicines had been developed for dealing with the diseases which they faced on a daily basis on the farm, and how these were an integral part of herd management. One commented that 'the [vaccination] needle [was] never out of [his] hand' (Int A5, dairy farmer), and similar logics of everyday progress may therefore be applied to technological development in other areas. Leach and Fairhead (2007: 5), describing the advances in developing human vaccines, argue that such developments contribute to ‘a powerful vision of technological progress.’ Progress appears to be lagging behind for TB.

Vets also mentioned how disease eradication had been successful for other diseases and laboratory diagnostics were pivotal in the success. In short, there was incredulity amongst both farmers and vets that the appliance of better science could not produce a better, more accurate test ‘in this day and age of DNA’ (Int A32). The potential for scientific mastery over nature was a powerful discourse, and one which meant if TB was eradicated in the future, other diseases could almost be eradicated at will:

> PR: ‘What would happen if TB was eradicated - what would happen to private veterinary practices in NI?’
>
> ‘There are plenty of other diseases. Pick another one.’ (Int A58, beef farmer)
>
> ‘Where we are at the minute is frustrating and is it's getting nowhere ... yeah, we are moving ahead with other animal diseases, and we are making an awful lot more rapid progress, but it's [TB] giving animal health government programmes a bad name really. We're running with brucellosis, but TB is just standing still.’ (Int A39, private vet)

The need is pressing, for ‘the will to mastery becomes all the more urgent the more technology threatens to slip from human control’ (Heidegger, 1977b: 313). The solution, according to one farmer, was to spend more on scientific research and development, and in his mind the DARD’s lack of ingenuity was to blame for the lack of scientific progress:

> ‘They haven't changed their way of going at all - it's the same old test for 50 years. All the Department did was took the money and spent it on themselves instead of spending it on trials. If they had ... I don't know ... is it somewhere around £22M every year they spend on it? If they had taken £1M every year and tried something different they might have had something today, but they didn't.’ (Int A29, dairy farmer)

But for others, they pointed to the complex materiality of TB and its defiance of scientific efforts to better detect the disease; bacteria and badgers were to blame, not the state:

> ‘They believe that bit [about failings in the test], because that allows them to say “Well I haven't got TB” or “I've got 100 reactors because you didn't pick out that one at that test - it's your fault.” It's not our fault - it's the fault of science - because it's the best we’ve got. We can't be blamed for using a tool that is not 100% successful if it's the only tool we have. It being a clever little organism [*M. bovis*] that has defeated us on the test in that we haven't got a test that works 100% ... It affects more than just cattle - at least with cattle we can test most of them during the year, but badgers [*laughs*] - we can't test them once a year.’ (Int A47, state vet)

The answer from both farmers and state vets was a blood test, and it was seen as solving the problems of both the metrologies and the performances of the skin test by being more objective, and removing the inconvenience of gathering cattle twice for skin measurements:

> ‘If they could ever develop a blood test for TB it would be nearly fool-proof, and it would mean that we would only have to round up all the cattle only once instead of twice, which would be good from our point of view, but maybe they can't do that.’ (Int A9, dairy farmer)

> ‘I would also argue that TB testing itself is a poor way of diagnosing disease as well. It is ... we all do the testing to the best of our ability and on some farms it is very easy to do it well, but on other farms it is not so easy to do it well. And I think it's a pity ... arguing against ourselves as far as work is concerned ... but it's a pity there wasn't a suitable blood test to diagnose TB. It would suit farmers far better, because they would only have to handle the animals once and something that was ... more definite’ (Int A46, private vet)

> ‘I think one thing farmers talk about is why they can't just use a blood test to detect it?’ (Int A16, dairy farmer)

But finding a new test in the laboratory has not been a straightforward proposition. The non-human agency affecting the politics of TB technology ‘forces political ecology to consider more seriously the known ecology, mechanics, genetics, engineering, and physics of the world in which struggles are enmeshed’ (Robbins, 2012a: 240), and to add to the list, the *immunobiology* too:

> ‘There was a big push for an alternative to the skin test ... From the first experiments that we did on this it was patently obvious that an ELISA

> wasn't going to be the answer, so we decided to go back to square one ... and that's what drove us towards looking for a cellular test, and that's what drove us towards the gamma interferon test ... If you compare the skin test and the gamma interferon test you had two overlapping populations that were infected. Both were picking up the bulk of the infected animals. The skin test was picking up some that the gamma interferon test wasn't and vice versa.' (Int A33, research scientist)

The expectation that the laboratory could quickly produce ready-made solutions from its black box of tricks is overly simplistic, and to adapt a phrase from Robbins *et al.* (2008: 110), there is no reason to assume that the diagnostic technologies can keep track of the 'rhizomatic and punctured spaces of the bugs they are charged with detecting'. Technology is indeed a 'mode of revealing' (Heidegger, 1977b: 319), but the complexities of *M. bovis* and the immune responses to its presence ensure that such revelations in the laboratory are often fraught with difficulty, just as in the field or the slaughterhouse (Frankena *et al.*, 2007). The interferon gamma test produces more false positives than the skin test due to lower specificity (Gormley *et al.*, 2013), and the highly complex nature of the antibody responses to TB infection continue to make the development of new serology tests challenging (Whelan *et al.*, 2011). In either case, it is likely that such tests could only be used in conjunction with the skin test rather than as replacements. Even laboratory technologies have their failings and contradictions (Mol & Law, 1994; Mol, 1998; Law & Mol, 2011).

Given the lack of progress, there is a mood of despondency and depression amongst many farmers, and not a few vets too, when they speak of the TB test:

> 'Well, they have been testing here since a long number of years - what have they achieved? They've achieved nothing. TB is as rife now as it was 40 years ago. I thought this business of testing was to eradicate the TB out of the dairy herd?' (Int A5, dairy farmer)

> 'But what really concerns me is that no matter how good the test is, the fact that we are not seen to be making progress means that a lot of farmers have very little faith in it, and some of our testing officers exude a lack of confidence in it, and just make a mockery of it ... I mean any weapon that you are using that is costing as much as the tuberculin test, if you don't

> have total confidence in it, you are going nowhere, because all the controls that are necessary for the test to be done properly are dependent on someone having faith in the test and doing it properly.' (Int A41, state vet)

There is a lack of belief, and that can turn into aversion towards the procedure. Farmers, especially those who had suffered prolonged TB breakdowns, spoke of the agonies of testing. They described it as 'soul-destroying' (Int A50); 'hassle' (Int A15, Int A26); and 'a waste of time' (Int A14). On top of the hectic lives which many farmers lead, testing was seen as an unwelcome burden to be fitted into an already overloaded schedule. It provoked some strong emotions of fear, nervousness, dread and even hatred:

> PR: 'Do you mind doing your test? Do you see it as a fact of life, or do you hate it?'
>
> 'I hate it.'
>
> PR: 'Why?'
>
> 'Because I just feel you are spending two days putting cattle through a crush, and there are always one or two who get injured in some way ... there's always something happens. You just feel it is two days wasted for absolutely no benefit to yourself.' (Int A16, dairy farmer)

Aside from the time cost, farmers outlined the economic costs of cows aborting during or after test; reduced milk yields and weight gains after the test; outbreaks of disease after stress and mixing of age groups; and unexpected and unpredictable injuries such as fractures through slips when handling. These added to the overall stress, and testing was viewed as 'hard on man and ... beast' (Int A14, beef farmer). One coping strategy for farmers was to treat the test as something that had to be done and to become immunized to it rather than dwelling on the work burden and the potential cost:

> 'If you're doing three or four tests a year [of 600 cattle] you just get absolutely immune to it, you just ... it's just another week of your life gone ... because that's what it is.' (Int A28, dairy farmer)
>
> 'It's sort of halfway between that [apathy] and boredom with the testing. It's a weird kind of a state. Were there extreme rules and real benefits and positive outcomes and things happening and all that, there wouldn't be

> apathy. But there's no end in sight - it has just become a bit of a routine, as long as the money flows. I tell you what would sharpen them up: if the farmers had to pay for it, I think they would be looking for a perfect test and perfect testing.' (Int A19, private vet)

Vets appeared to be immunized to testing, but in a different way. Some spoke of it as a way to 'switch off', and they enjoyed even a full day of testing because it offered relief and a certain predictability when compared to the vagaries of farm calls in busy calving and lambing periods. It was also seen as a social event when they could discuss trivialities with farmers, but also to catch up on farm business news. Others viewed testing as merely something to be tolerated, but a welcome boost to the practice income. If TB was eradicated and testing stopped or if testing was lost to lay personnel rather than vets, there was universal agreement that many vets in NI would be unemployed, and farm practices would have to down-size and re-structure. But over a generation of life in veterinary practice, not much had changed, and everyday life in the world of TB went on as before:

> PR: 'How have things changed with the TB situation over your career? Have they changed?'
>
> Vet 2: 'No [*very definite*], basically. Bottom line - we are still chasing it just as much as we were 30 years ago. We are better organised perhaps, and better monitored - we know more what's going on, but in terms of an endemic, chronic, hard-to-diagnose disease we are not significantly better off than we were 30 years ago.'
>
> Vet 1: 'As Frank Smith [*pseudonym*] always said in his talks about life skills: "If you always do what you have always done, you always get what you always got" [*all laugh*].' (Int A46, private vets)

The despondency and frustration feed into an ever-downward cycle of depression and despair that nothing ever changes – all stays the same. Neither do human emotions appear to change much over time, for Bang (1908: 292) found that after the initial enthusiasm had waned, farmers were prone to listen to many voices 'eager to assure him that the tuberculin test was mere humbug'.

A complex and unruly assemblage - the 'black box' of TB technology

We have seen how the TB test has multiple facets and characteristics: science through metrology, performance, witnessed by diverse actors, and has lost the faith of many. Lastly we consider the complex, unruly assemblage that is the testing technology, difficult to govern, and hard to manipulate. This is not surprising, for Mol and Law (2002: 21) declare 'that which is complex cannot be pinned down'. The complex technologies of TB consist of tuberculin, syringes, calipers, bovines and people. At a different scale, they consist of immune reactions and fluids within skin surfaces. They also constitute numbers and statistics. Mort (2002:17) states that 'once a technology has been adopted and stabilized ... the bulk of this complex, heterogeneous world often sinks out of sight'. This chapter has demonstrated that although the technology of the TB test has been adopted and has been used for many years, it is still far from accepted, and remains unstable and contingent. There remains room for further 'heterogeneous engineering' (Law, 1987: 111).

For vets, the 'black box' (Latour, 1987:1-17) of TB technologies may have been closed, and the science and its uncertainties are generally accepted. The test is what it is - there are mysteries for sure - but it's the best there is, so they carry on using it, and it pays well. Policy changes are for the state to worry about. For the farmers, the box is open – it is all to be challenged, all to be resolved – the test does not work and is unreliable; creates hassle; and they generally have little faith in its usefulness. This can spill over into anger and resistance.

There is a need for the state to enrol humans to believe in the 'black box', but also for non-humans to comply. For the TB test, these non-humans often do not align very well: cattle jump and evade groping hands; rain falls; calipers fail to grasp the fluid boundaries of oedematous swellings; immune cells do not react to a latent presence; 'peas' don't form when tuberculin squirts and drips; syringe needles bend and miss the target. Like the haemoglobin meters sent to far-flung corners of Africa, technologies struggle to cope at the 'limits of the network,' outside of the safe spaces of the confined and regulated laboratory (Mol & Law, 1994: 650).

But most importantly, the technologies of TB testing are about *people*. The simple instrument of skin measurement allows 'action at a distance' (Latour, 1987: 254), creating numbers for vets to compare to the grid; to classify and decide whether to retain, reject, or revisit. But the lay experts, the farmers, see the uncertainties in the mind of the vet, the dirt, the rainy day, the cold fingers, and they know that the test misses a percentage of animals, and it falsely classifies others as reactors. They know there are failings, and they doubt, and do not believe. They know that perhaps they can cajole, or persuade, or challenge (or threaten?) the vet – and perhaps they will let it pass – after all, there are so many uncertainties at work – why not give it the benefit of the doubt? Others, the unscrupulous ones, take matters into their own hands and either create false reactors through their own kinds of 'injections', or else make reactions 'disappear' depending on which way they want the test to turn: compensation for 'reactors', or freedom from restriction.

In this political ecology of the TB test, it is clear that technologies can have *political* qualities (Winner, 1986; Law, 2008b), and the technologies of TB testing have become an 'eminently social and political problem' (Callon *et al.*, 2011: 25). The sense of hopelessness and struggle to keep faith in the technologies of TB is not only due to the scientific and technical indeterminacy of the test; clearly the uncertainties of the people involved play the major role in creating a politics of controversy (Callon *et al.*, 2011). Farmers play politics with vets; private vets with state vets; and the local politicians and European Commission challenge the state's role in the chain of explanation. Building a technical democracy such as

Callon and his colleagues espouse will be a great challenge for the future, especially when the testing programme has become intrinsically linked to disputed lay and expert knowledges of the disease. Testing and the disease may even be ontologically and epistemologically one and the same:

> PR: 'So what do put all your TB problems down to then?'
>
> 'I don't know - I can't answer that question. I wish I could tell you what the cause of the problem was. I haven't a problem with the TB - the only problem I have is the testing every 3 months - that's the biggest heartache.' (Int A7, beef farmer)
>
> 'For farmers and vets, this is not a real disease - this is a programme. The programme itself *is* the disease.' (Int A56, state vet)

For farmers, is TB eradication therefore about the eradication of an infectious organism and a disease, or rather a fervent desire for the eradication of the *technologies of detection*? As one dairy farmer suggested, a farming world without testing would be 'bliss' (Int A44). But such a world, it appears, is a long way from reality, and in the meantime a 'politics of conviviality' (Hinchliffe & Whatmore, 2006) mean that there must be an accommodating living-with this technology, rather than living-without. Many can legitimately ask if it is 'the right tool for the job' (Bickerstaff & Simmons, 2004), but despite the overflows and miscalculations, it (unfortunately) remains the best there is. After all is said and done: 'If the world is messy we cannot know it by insisting that it is clear' (Law & Singleton, 2005: 350). The blend of indeterminate and uncertain science, performance, regulation, unruliness, doubt and despair does not bode well for future success in eradicating TB through tuberculin testing. The whole process has arguably become an interminable performance cycle where trust and belief long since departed. Efforts to find alternatives to the SICCT test must be intensified, but even with a better test, the ecologies of TB pose another serious challenge to efforts to eradicate, as shall be explored in Chapter 7.

Chapter 7: Ecologies of TB: the spread of a disease

Ecology, states Walker (2005: 78), is 'the study of the interrelationships between living organisms and their physical environment'. He emphasizes the need to account for the biophysical relations and materiality in any analysis worthy of the name of political *ecology*. This type of approach weaves together 'analyses of relationships between broad political and economic processes and on-the-ground physical [and biophysical] processes' (Gezon, 2006: 21). Significantly, Moore (1996: 125) goes so far as to say that 'ecological processes [cannot] be understood outside of the contexts of local productive relations and wider economic systems' in which they are situated. Petersen and Stuart (2014) criticise the tendency of many political ecology scholars to overlook non-human and ecological factors in their analyses, but suggest ecology is coming into sharper focus once again. This has relevance to understanding the ecological actors and processes shaping the spread of TB in NI at variable scales.

Firstly, consideration of land use and landscape is important. Cattle farming is conducted at high stocking densities (amongst the highest in the UK) and with ever-increasing herd sizes across multiple and uniquely fragmented farm holdings. Land is at a premium, and farmers maximise their use of the grass, often bringing cattle into contact with other cattle in contiguous neighbouring herds. Farmers purchase and rent land wherever it is available, even if it means travelling miles to access it and despite the added labour costs; such is the desperation for more land. The landscape is fractured by diseased herds and wildlife and it is a struggle to separate 'healthy life from diseased bodies' (Hinchliffe *et al.*, 2013: 531).

Secondly, the movement of cattle, badgers and bacteria is also important.

Farmers move cattle because trading livestock is fundamentally important to the economies of farming. In addition to generating flows of capital, it is deeply engrained in the psyche of many as a cultural and social activity. Cattle meet cattle from other herds in markets whilst on the move, and in adjoining fields at pasture, contributing to between-herd spread of infection. Badgers and deer also move on farmed land, meeting cattle as they go. Additionally, the bacterium moves, or is carried, from one animal and from one species to another, and new social relations are brought into being between the microbes and their hosts. The social and the material entwine to create disease landscapes influenced by, and influencing, economics and politics (Scoones & Wolmer, 2007). 'Entangled' landscapes (Ogden, 2011) of humans and non-humans are the result.

Focusing on both the connectivity (Goldman, 2011; Etherington *et al.*, 2014) and particularly the fracturing of the farming landscape, this chapter uses the idea of a *diseased* landscape to help think through the ecologies of TB. It also uses the concept of *mobility* from cultural geography and STS literatures to analyse a landscape in a state of flux created from animal movements, both farmed and wild, together with the TB bacteria which they carry and transmit, further developing the framing of TB as a mobility in Chapter 5. Looking at the 'dystopic qualities' of rural landscapes (Cloke, 2013: 230) and their disruption through disease (Jones, 2013), this concerns the unravelling of ecological forms and processes for TB transmission in the countryside. As the two veterinary interviewees suggested below, there remain gaps in understanding the fundamentals of TB transmission, emphasizing the utility of such endeavour:

> 'I think there's not been enough research done on the spread of TB - how it spreads.' (Int A10, private vet)
>
> 'How is the dang thing spread?' (Int A19, private vet)

Rather than 'therapeutic landscapes' (Gesler, 1992), this chapter therefore investigates the ecologies which constitute 'pathogenic landscapes' (Lambin *et al.*, 2010) based around the relations between places, land use and farm fragmentation, alongside cattle, wildlife and microbes on the move.

TB in place

At one scale, disease landscapes appear to have predictable patterns: TB in NI is clustered in time and space (Skuce *et al.*, 2010; Biek *et al.*, 2012). This is recognised by the state veterinary authorities, and disease investigation involves mapping and testing neighbouring herds surrounding TB breakdowns to detect possible spread and origins of infection. Farmers and vets also use spatial discourses to speak of the disease. Disease outbreaks are linked to particular areas, and even fields, with divisions of land into 'good' and 'bad' places for TB. Those who had suffered TB breakdowns often described how their neighbours had either previously or subsequently been affected. Areas which had been free of TB until recent times suddenly became hotspots of the disease, with contiguous herds being declared positive in a domino effect. One vet spoke of areas always linked to TB, and also of particular fields which were 'infected places' at a finer resolution:

> 'To be honest with you, I have been working in the same practice now for coming up on 30 years, and the sad thing is that some of the TB hotspots that we have now ... are exactly the same hotspots that we had when I came into our practice.' (Int A40, private vet)
>
> '[TB reactors] bang on the same field, on the same piece of ground, where I took out the last seven or eight TB reactors nine months ago.' (Int A40, private vet)

Whilst other places remain free of disease, certain localised areas are 'ambiguous landscapes' (Collins & Kearns, 2007) without recognisable pattern, unpredictably harmful *or* healthy depending on the year, and confounding attempts to forecast presence:

> 'The area [of TB] moves within the area. We would have had ground in the past beside glens, and you would say "Yeah, that's where it came from -

> that glen". And then the next year the cattle on that same ground can be clear of TB, and it's ground you wouldn't think of where the cattle can be going down.' (Int A29, dairy farmer)

Despite the ambiguity on occasions, there appeared to be a simple solution to coping with infected places – avoidance. A dairy farmer testified that after several years of having TB reactors on the same outfarm he gave up grazing the ground, for a while at least:

> 'So they took seven cows away [as TB reactors] the last time. I got really annoyed with it, and the following year I just took the third cut silage off this ground, and I done [sic] that ever since until this year. So maybe I could tell you better next year what the consequences are with the cows up there at the minute. But once I stopped putting cattle there TB disappeared from my herd - it was completely clear - last two tests I had were completely clear.' (Int A5, dairy farmer)

Research has shown that *M. bovis* can survive in soil under natural weather conditions for up to 88 days (Fine *et al.*, 2011). These infected places may therefore have been due to environmental contamination of the soil by TB bacteria from the occupancy of previously infected cattle or from contaminated slurry spread on the ground (McCallan *et al.*, 2014), but these factors were not mentioned. Rather, TB and place were often linked to the presence of badgers on the land. Certain fields were deemed 'full of badger setts', or were adjacent to areas of gorse or scrub land suitable for badger habitats. Even the rural landscape was deemed especially suitable for badgers and part of the problem of why TB persisted:

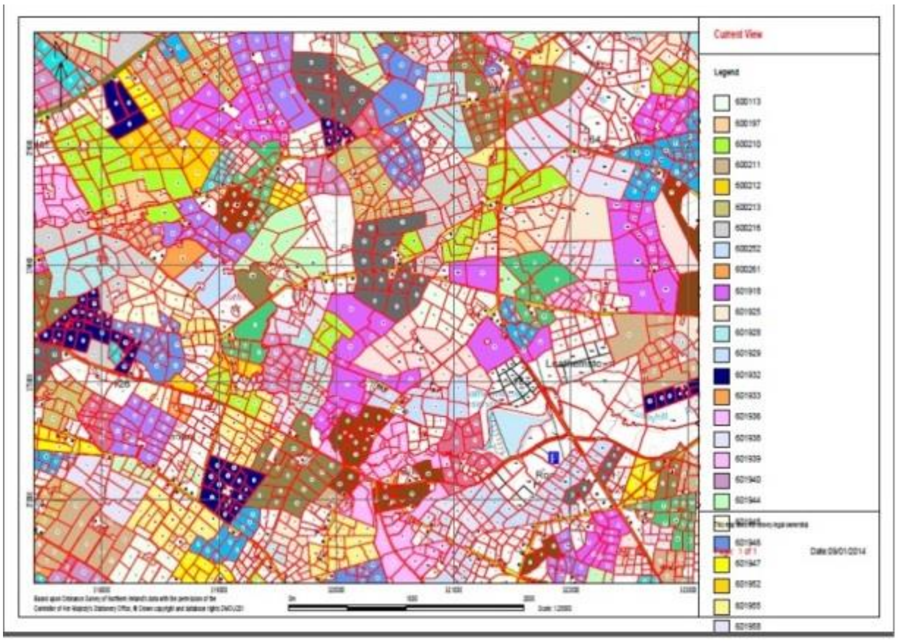
> 'If you go half a mile on the other side of [local village] there's a bad area in there … and a lot of holes for old badgers. It's full of badgers, and everybody gets TB in that area.' (Int A9, dairy farmer).

> 'Then the terrain - drumlins and rolling hills, soft land, boulder clay - easy for the badger to get his little nose into and dig holes.' (Int A40, private vet)

In other places deer, especially close to forests, were linked to TB breakdowns, although this was deemed nowhere near as common as badgers.

Cattle too are linked to place - to particular farm holdings and particular fields based on who owns and manages their movements at pasture. Viewed from the air, the farming landscape of fields resembles a patchwork quilt, represented in colourful DARD mapping systems used for subsidy schemes (Fig. 8). The land is fractured and divided up by boundaries of hedgerows, fences and stone walls. Looking at the map, the land parcels belonging to, or rented, by the same farmer (matched colour for each farmer), can be separated and isolated from each other rather than remaining in one block.

Figure 8: GIS representation of farm holdings in NI (Source: DARD)



Such maps become important in disease outbreak investigations, because the boundaries between fields and between animals appear to be porous - disease mobilizes across the landscape and animates it (Rose & Wylie, 2006). This concept of flows across boundaries is not novel – it is found within ecology (Wiens, 1992), and includes material flows within agricultural landscapes (Ryszkowski, 1992). Similarly, landscape ecology uses geographical concepts of scale, boundaries, edges, mosaics, networks, flows, movement and connectivity (Forman, 1995). Place can therefore be regarded 'not as a container, but as a nexus of relations' (Rocheleau, 2011: 224), and these places are not the 'flat surfaces' (Law & Mol, 2011: 13) which maps may suggest, not merely an arrangement of patches of colour (Fig. 8). Beyond simple polygons of farm land and fields, these networks of relations between humans, animals and microbes are linked to 'production, circulation, extraction, consumption, and transformation' (Rocheleau, 2011: 215) of, and on, the land. As Mayer (1996: 451) states: 'Disease can be an unintended consequence of development, agricultural or land-use policy'.

There were repeated suggestions from both the private and state vets interviewed that the system of conacre and farm fragmentation, with the associated animal movement between parcels of land, was part of the explanation as to why TB had not been eradicated, and an obstacle to further progress. Abernethy *et al.* (2006) and Robinson *et al.* (2014) also hypothesize that the fragmentation of farms and extensive use of conacre in NI has contributed to the ongoing transmission of TB. But why are farms fragmented, and why do farmers use conacre? This topic was first raised in Chapter 3 on the history of TB, but to further answer these questions, the next section will describe in more detail land use policy and the ongoing scramble for land in productivist agriculture. Land uses, and the economies of land purchase and rental, influence the networked material flows of cattle, wildlife and microbes within the landscape of TB.

Land use and fragmentation

In the summer and early autumn grazing cattle are common features of the landscape in NI. However, the land on which they graze is a valuable commodity in short supply, with ever-increasing demand. The difficulty for many farmers is acquiring enough land to support the size of farm enterprise which they aspire to maintain. This is by no means a new problem, but it perhaps differs in scales of economy. Though first published in the late nineteenth century, the applicability of Eduard David's thoughts on agricultural production are relevant to today's situation: 'The agrarian capitalist must wait for the opportunity to buy land, if he does not want to pay fancy prices ... The land cannot be increased in size at will, nor can it be moved from place to place. This makes for a certain inflexibility in the area within which production is carried on' (David, 1984: 8-9). Farmers seeking to expand their dairy or beef enterprises are limited by the amount of grazing land available to them for purchase or for rent, which severely frustrates their productivist instinct:

> 'Land here is very scarce, and if you have ambition to have a few more acres, and you just can't get them, I can certainly understand people selling up [and moving to GB].' (Int A28, dairy farmer)
>
> 'There's no use in building sheds if you haven't the stock to put into them. And then I'm tied here by the area, to the size of my farm, because I'm surrounded by dairy men, and I haven't a hope of survival among them, because they seem to want all the ground that's going, and they think of nobody only themselves.' (Int A14, beef farmer)

It appeared that smaller, more marginal, beef farms were unable to compete with the purchasing and leasing power of larger dairy farms. Land is a limited commodity, and this theme came through very strongly from the interviews, particularly from dairy farmers.

The trend to increase farm size has changed the farm landscape quite dramatically over the past century. In 1926 eighty-six per cent of farmers farmed less than 50 acres of land (based on Armstrong, 1989), but by 2012 this proportion had decreased to forty per cent (based on DARD, 2013b). The assumption can be made that the majority of these farms are managed by part-time farmers who have additional employment outside of the farm. Significantly, these forty per cent of farmers only farmed ten per cent of the total farmed area in 2012, demonstrating that the vast majority of the land was controlled by larger farms with larger cattle herds. Farms are increasing in size as land becomes available for purchase, enabling bigger herds to be maintained. The disadvantage is that the farms are becoming increasingly fragmented as a result, with multiple separate holdings rather than land in unified blocks:

> ‘I have been farming here since I left school after my father and my grandfather had expanded it over the years from 57 acres to over 500 acres now.’
>
> PR: ‘Livestock-wise, how has it grown?’
>
> ‘Whenever I was leaving school there was a 24-cow byre, and now there are 400 milking cows.’ (Int A11, dairy farmer)
>
> ‘We're hemmed in. So actually we have bought ground … first of all nine acres half a mile that way; then 34 acres beside it; then 74 acres a mile and a half that way; and I bought 54 acres last year five miles that way [*waving finger in various directions*]. So NI’s biggest weakness is the fragmentation.’ (Int A32, dairy farmer)

Apart from purchasing land, another common solution is to rent land to allow expansion of production. The system of short-term land lettings known as ‘conacre’ is a particular feature of land tenure in Ireland, and 46% of farms in NI had a mixture of owned and rented land in 2013 (DARD, 2014a). Back in 1963 only 15% of land was in conacre arrangements (Woods, 1963), but even then there was a trend towards increasing farm size through renting ground to expand production by those who could not afford to buy it. Although many farmers have stable conacre arrangements which mean that they rent the same land year on year, others are in precarious arrangements dependent on finding suitable land each year to support their enterprise. Some were concerned about potential changes in land ownership and loss of rental ground with the collapse of their farm, and this encouraged thought of leaving home to buy land in Scotland, following others who had gone before:

> P1 (Father): ‘If I could get a 400-acre farm for my dairy cows, and 600 acres of a hill for these boys' sheep, I would go [to Scotland] tomorrow.’
>
> P3 (Son): ‘We're squeezed over here for ground, we can't get ground … We have a big farm, but it's all rented//’

> P1 (Father): '// It's all rented. We have 170 acres here in the middle of her, but the rest of it's conacre, and to go out and buy any of these farms - you would put your light out.'
>
> PR: 'So you think the ownership of land is very important for a farmer then?'
>
> P3 (Son): 'Well, next year this man could die over here, and we have 180 acres of it [rented]' (Int A6, dairy farmers)

> 'I suppose farmers in NI - it's small ... you're fighting for space. It would be nice to go to Scotland and buy three or four hundred acres and have it all round the yard, but that doesn't happen here, you know? A lot of people rely very heavily on conacre, and some of it is all over the place ... We do too - we rely an awful lot.' (Int A8, dairy farmer)

> 'The thing is that a lot of these wee farms here ... there are very few people who have a farm big enough to carry the stock that they are carrying. You are renting ground here, there and everywhere to be able to keep them, and if you could get a lump of land all down the one lane, it would be great.' (Int A9, dairy farmer)

Fighting for space, cattle farmers are practising their own form of 'land grab' (Nally, 2014) and many are caught up in the 'struggle for land' (Wolford, 2004). Global markets create the struggle, producing a drive for farmers to increase profitability or alternatively, just survive. As Crang (2004: 90) argues, 'fields ... are far from just material features but are etched with these external forces'.

This is not unique to NI, for Wolleswinkel and Weersink (2001) found that the intense desire to expand farming operations had driven farmer emigration from the Netherlands to Canada, but it is probably more significant in NI than in any other region of the UK. Both farmers and vets emphasized the differences in farm structure in NI compared to other parts of the British Isles, and a vet compared his experiences of farming in North Yorkshire, noting the extra emphasis on rented land use in NI:

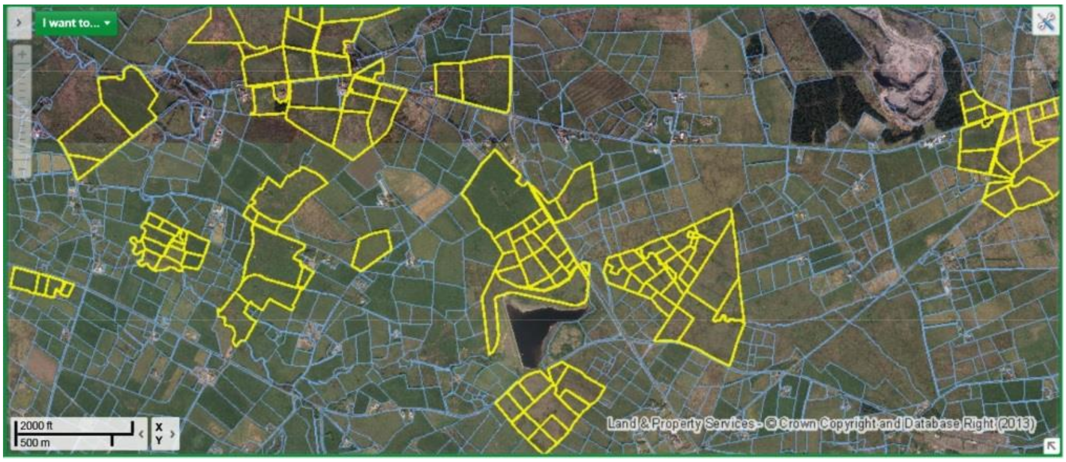
> PR: 'Do you think there is a difference between the dairy and beef industry in England compared to here?'
>
> 'There is certainly in terms of the scale of the industry here compared to across the water, and even down South [ROI]. It is also very different in

terms of farm size, and the fragmentation and conacre here. NI is different - that is the big claim in everything - but it is true.' (Int A62, DARD official)

> 'Similar size of farms around there actually to here, but completely different ethos. There each farmer owns his own ground, and he farms his own ground. Here they tend to farm their own ground plus bits and pieces of everybody else's ground.' (Int A48, private vet)

The net result of pressure to acquire land is the fragmentation of farm holdings, with multiple holdings being part of the same business enterprise, and parcels of land scattered often at some distance farm the main holding (see Fig. 9). This effect of political economy has implications for the spread of TB, with herds being exposed to multiple other herds across farm boundaries in different areas, and continual within-herd movements of cattle to the land parcels within the same enterprise.

Figure 9: GIS representation of field boundaries of land used by one cattle herd in NI (Source: DARD)



As these vets explained, the geography of cattle farms was a significant and integral feature of productivist farming life:

> Vet 1: 'Even within those smallholdings maybe a farmer has a field here, and another field three miles away - they're distributed everywhere. I think whenever you get down to the geography of it, with so many different herds all scattered everywhere the current, as I see it, the current level of testing can only hold TB at a certain level, but we don't seem to be making inroads on it.'

> Vet 2: 'They have ground everywhere and they would be back and forth ... It [conacre] just has to be taken, and they don't really consider if it's a TB

> area. It's something that maybe needs to be looked into more, but the problem is that ground is something they are not making any more of, so it's hard to say to them ... if they don't take the ground then maybe they need to cut back in numbers. There are bigger implications about not taking the ground.' (Int A59, private vets)

Comparisons were made between NI and Scotland's TB-free status, and the difference in land use patterns was emphasized as the differentiating factor in spreading and acquiring the infection:

> 'I think that a lot of men here [in NI] have rented ground. Scotland is free of TB. But a guy there has 300 acres in one block, but if a guy here has 300 acres he has 100 here, 30 there, 20 there ... so if a guy goes down [with TB] his cattle are all over the place.' (Int A40, private vet)

> 'You have to, say, look at Scotland. OK, Scotland is a bigger area; there's less animal density; there's probably less of a wildlife problem; there's less movement. Animal movement ... conacre ... cattle all over the country ... one man has 500 cattle in ten different sites, and they move them about with impunity. And that is bound to be a problem, almost unique to NI.' (Int A46, private vet)

> 'I put down a guy [reactors at TB test] last January - he's got about 1,200 cattle scattered all over the place, and he's a dairy farmer, and, you know, that's huge [*laughs*].' (Int A43, state vet focus group)

Epidemiological research emphasizes the importance and relevance of these land use and herd size features. A recent biosecurity study involving 117 TB case farms and 75 control farms in Co. Down, NI (O'Hagan *et al.*, 2013), found that a high percentage of farmers used conacre land (83.8% of case farmers and 78.7% of controls). Case herds had an average of 9.37 boundaries with neighbours, and the total number of land parcels which constituted the farm enterprise ranged from 1 to 16, with an average of 4.39 parcels for case herds and 3.33 for controls (O'Hagan *et al.*, 2013). In another NI study, Robinson *et al.* (2014) discovered that TB-infected herds had between 2 and 135 contiguous herds (mean 19.5) within 50 metres of their land boundaries, and herds contiguous to infected herds were 1.53 times more likely to develop TB themselves. Abernethy (2008) studied within-herd movement patterns for a sample of 69 herds and found that they grazed a range of between two and nine separate premises (median of three), with up to 35.5 km between them (median 2 km).

This landscape fragmentation has consequences, and may increase the incidence of TB infection through increased movements and connectivities between the parcels of land. Conacre land, often associated with TB breakdowns in my research interviews, could be a significant part of the problem of land use and TB, and may be a significant difference affecting eradication prospects in NI compared to elsewhere:

> Vet 1: 'Well they have eradicated it in European countries as well, haven't they?'
>
> Vet 2: 'Yes, most of Europe has eradicated TB using the skin test.'
>
> Vet 1: 'Yes - using the skin test.'
>
> Vet 2: 'Yes, but most of Europe doesn't have conacre.' (Int A46, private vets)

Whilst land may often be a cause of consternation and farm insecurity, farmers showed more confidence and reassurance when talking about their cattle. But cattle movements are also part of the ecologies of TB spread, and as we have seen, related to the quest for bigger herds and more land.

Moving cattle - bovine mobilities

Cattle are constantly on the move in everyday farming practice in NI, being traded through markets and directly between farms. They move individually significantly more often than in the rest of the UK. A network of cattle dealers buy and sell cattle, circulating between markets and around farms in addition to the direct trading that farmers conduct between themselves and through auctioneers. Even within farm enterprises cattle are moved from one land parcel to another, alternating grazing and rest periods for the land, and providing the grass needed for growth and milk production. These movements provide multiple opportunities for contact and exchange between animals within the same herd and between herds. Movement of cattle is certainly recognised in veterinary science as a risk factor for the spread of TB (Green *et al*., 2008; Gates *et al*., 2013), and the connectedness of cattle farms in a network determines the potential for the spread of infectious disease through movement (Volkova *et al*., 2010). However, it may be more useful to think more of these movements as *mobilities*. The notion of mobility conveys something more than merely movement, for as Adey (2010: 13) writes: 'Mobilities almost always involve a kind of transformation of the contexts and spaces they occur through'. In the context of bovine mobilities, the buying, selling and transporting of cattle around the countryside continually *changes* the disease landscape. The landscape is never the same on two consecutive days, and the arrangements of animal bodies produce new opportunities for acquiring and transmitting infection.

Suggesting an analysis of bovine mobility extends the boundaries of human geography just a little further. Adey and Anderson (2011: 12) think there is an 'under-examined relation between mobility and materiality'. Scholarship on animal mobilities is not common within the geographical literature (but see Bull, 2011a; Bull, 2011b; Bear, 2012). However, in literatures influenced by STS, Law (2006: 228) explicitly linked *animal* mobilities with *disease* mobilities when considering the relations between the movements of animals, particularly sheep, with the spread of FMD during the outbreak in the UK in 2001. Similarly, Enticott (2008a; 2008b) discussed the mobilities of TB within agricultural farm space when considering the spaces of biosecurity.

The state urges farmers to keep 'closed' herds in biosecurity discourses aimed to persuade farmers to avoid purchasing infected cattle (DARD, 2004). The risk of spreading TB from bovine mobilities is certainly supported in recent veterinary research findings in NI. O'Hagan *et al*. (2013) found that farms which had TB breakdowns in the Co. Down biosecurity study were 4.6 times more likely to have purchased cattle in the previous three years than control farms, and just 22.9% of all farms in the study were 'closed' herds with no purchasing. Bulls were the most commonly purchased type of animal, with around a third of farmers in the study stating that they had bought a bull in the previous three years (O'Hagan *et al.*, 2013). In my research, the majority of cattle farmers reported that they bought cattle into their herd. Of the 29 farmers who specifically talked about their purchasing policy, just 5 had a completely closed herd. Others bought only occasionally, most often a breeding bull, but tried to maintain a closed herd (16). The remainder (8) bought animals very frequently or fairly frequently, particularly beef farmers.

Dairy farmers appeared to be more reluctant to purchase than beef farmers. Some beef farmers bought regularly and their business model was based around buying in cattle for further production, particularly to fatten for slaughter. Reasons to buy stock varied, but this was mainly an economic decision, with some farmers suggesting that they could purchase cattle at a price which was cheaper than having reared the animal to the same stage on their own farm. Others had reduced their suckler cow numbers due to falling profit margins, and could no longer rear their own replacement heifers, forcing them to buy in. There was also a socio-cultural aspect to purchasing cattle, with traditions of attending cattle markets as a cultural and social event, not particularly influenced by economic reasoning. When asked why he purchased animals regularly from markets rather than from individual farms, one beef farmer answered:

> 'You could go to ten farmers, and you could find one that has the type of animal I'm looking for.'
>
> PR: 'So the market gives you//'
>
> 'It gives me the choice - they are in front of me, they are there in the ring.'
>
> PR: 'Do you enjoy buying cattle?'
>
> 'I do, yes.'

PR: ‘Why do you enjoy it?’

‘Because it's part ... it’s part of my life ... It's a challenge, but I like a challenge.’ (Int A7, beef farmer)

This farmer therefore combined the economic and the social reasons for his regular visits to markets, and others agreed. The market was a place to meet friends and catch up on gossip, as well as a place to do business. A dealer-cum-beef farmer also spoke of his enjoyment and fulfilment in trading cattle, and compared his attitude with dealers who did not farm, and were deemed not to care about the animals which they mobilised from place to place as commodities:

‘I did enjoy it. I liked the banter of buying in the ring and privately around farms and selling them. Every one was a new challenge .... To me, some guys are addicted to bidding - they put themselves out by buying and bidding. I liked bidding and buying, but my suckler cow at home was the backbone ... The suckler cow to me was the main thing, and those dealer men would not calve your cow - they were just buying cattle and taking them away to somebody else, and they had the money in their pockets and that was it.’ (Int A21, cattle dealer and beef farmer)

Abernethy *et al.* (2000) found no evidence for increased risk from animals moved through markets in NI, but cattle markets could in theory be assemblages of stressed animals shedding bacteria to others they come into contact with, creating a TB ‘soup’:

‘My humble opinion is that we have a soup of [TB] infection most days at [the] market and we just can ... [*makes slurping noise*] ... spread it out again’ (Int A47, state vet).

If cattle trading is part-business, part-necessity and part-pleasure, the practice does not meet with the approval of many vets. Indeed vets repeatedly raised the culture and practice of trading cattle in NI as one of the reasons for the failure to eradicate TB:

‘Farming in NI ... that's possibly part of the problem too, the constant movement of animals. The daily movements moving from farm to farm are colossal. The number of animals moving through the markets every day in NI - and that's just through the markets - there are also plenty of private movements from farm to farm too.’ (Int A17, private vet)

> ‘Joe Blogs decides: “Oh it's Tuesday - it's time to go to the market. I'll take some of those beasts to the market and see if I can't get rid of them, and I need some as well.” So off he goes to the market, and it's: “There's a good-looking beast there - I think I'll buy that one.” It never occurs to them – they never have a thought in their mind about asking where the animal came from; what its animal health history was.’ (Int A61, state vet)

For ‘good’ farming in the minds of vets, accountability for cattle mobilities required more than reporting movements to a state database and abiding by regulatory standards (Singleton, 2012), but care and responsibility towards cattle also meant thinking of reducing disease spread. Vets often cited the much lower levels of movement in Scotland and England, and one state vet described the frequent movements in NI as ‘bonkers’ (Int A43, state vet focus group). A few farmers were keen to emphasize they maintained completely closed herds, and others adopted defensive poses when asked about their purchasing policy, suggestive of guilt that they thought the practice was somehow less than advisable and not something to be admitted; state biosecurity discourses appeared to have touched the conscience at least. Even if closed herds were maintained, there was always the risk from neighbours. One was fearful because his neighbour bought high volumes of cattle, and was deemed a high risk contact. Cattle dealers and unscrupulous farmers who operated outside of the law in an underground economy came in for criticism, and movement (both legal and illegal) was explicitly linked to ongoing TB spread:

> ‘The biggest threat in NI is still the unscrupulous cattle dealer, who is moving animals ... without permits; moving stock from herds which may either have inconclusives or reactors ... These guys are only interested in making money ... [If] every farmer in NI strictly adhered to moving animals the way they should do by law then we would probably either be getting close to TB-free or would have a TB-free NI.’ (Int A18, dairy farmer)

> ‘I think the worst statistic I heard about [cattle trading] was the calf which arrived on someone's farm two weeks before a TB test. It was positive at the TB test, and whenever it was checked back, it had been presented at 11 different markets in the previous three weeks [*laughs*]. With that sort of thing it is no wonder you're going to get an increase in TB incidence!’ (Int A49, private vet)

The proposed veterinary solutions to reducing mobility were to use artificial insemination and embryo transfer to introduce new genetics into the herd while avoiding purchasing bulls or replacement cows. If purchase was deemed necessary, vets suggested purchasing from known disease-free farms, or at least to find out TB history of animals in markets before purchasing. TB breakdowns restrict bovine mobilities for a season, with the state preventing infected herds from selling cattle unless directly to slaughter. This is regarded as one of the most unfortunate and unwelcome aspects of having the disease by farmers. Such periods of restriction produce build-ups of cattle on farms which would otherwise have moved on, and the pressure of excess bodies to feed and house can build on the farm until the dyke is ready to burst, to use Law's (2006) analogy. To avoid such a scenario, one oft-used tactic is to offload cattle *before* the TB test in anticipation and pre-emption of possible disaster (Anderson, 2010). The flow of untested animals potentially harbouring infection moves the problem onto other farms, leaving the state to track and follow-up *after* the TB event has taken place.

The difficulty is that microbial mobilities can continue even when cattle movements have been slowed down or halted for a season. During the winter housed period, when cattle return to home base to be fed silage and protected from the vagaries of the climate, there are still multiple opportunities for contact operating on a different scale between animals within the *same* herd:

> 'Forty years ago it was a picture to walk into a byre and see 40 or 50 cows tied by the neck. TB, for nine months of the year, was contained - if she brought it into the byre, maybe the one next door got it, in the adjacent stall, but the rest of the herd didn't get it. Nose-to-nose contact in former times wasn't as great. Nowadays cows are in head-to-head cubicles, open areas …' (Int A58, dairy farmer)

Badgers may also gain access to farm yards and cattle housing, attracted by offers of nourishing food-aplenty (Sleeman *et al.*, 2008; Tolhurst *et al.*, 2009). Despite all of these risk factors, TB spread is unpredictable and indeterminate. Cattle mobilities do not always seem to produce infection, or if they do, these incursions often go undetected. A few farmers asked how animals in a market could be a problem, and assumed that if the herd was free to trade and without current TB restrictions then they were purchasing in good faith. Closed herds were seen by some farmers as the ideal scenario, but unrealistic given the economics and vagaries of farming life. They felt that a closed herd status could not be maintained when disease outbreaks or infertility required the purchase of replacement stock. Ironically, large TB breakdowns caused some farmers who would otherwise have maintained closed herds to reluctantly purchase animals afterwards to re-build the herd.

Bovine mobilities may, or may not, have a role in TB spread, depending on the circumstances. A beef farmer whose beef fattening operation was based on the purchase of cattle was willing to take the chance, and the risk from his experience appeared to be low:

> 'The remarkable thing from my own experience - it's a stupid thing to say this - touch wood - but I would have been buying and selling quite a few cattle ... certainly buying from everybody under the sun in markets, and the vast majority of the time I have no problem with TB, and yet my neighbours right round me - mostly dairy farmers, mostly self-contained units - often have problems. How is that? That, to me, is the remarkable thing.' (Int A58, beef farmer)

As with so much else about the disease, mobilities can have indeterminate effects, encouraging many to continue trading whilst accepting the risk. What then of badgers, so famously and controversially implicated in the politics of TB in the UK?

Badgers (and deer) – significant 'others', or cosy companions?

Farmers and vets were absolutely convinced that badgers have an important role in the ecologies of TB spread in NI. There were repeated stories of badgers being connected to TB outbreaks in cattle. Of all the farmers I interviewed, only one or two questioned their role, but even they were hesitant to rule them out. Vets varied in their opinion of what proportion of cattle breakdowns were due to badgers, but all were agreed on at least some contribution from the infectious badger, with a suggested range of between 10% and 90% of outbreaks. These views are not uncommon elsewhere in the UK and ROI. Badgers are regarded as an important part of the epidemiology of the disease in cattle in both GB (Godfray *et al.*, 2013) and the ROI (Corner *et al.*, 2011), and more recently their role in TB has been investigated in Spain (Balseiro *et al.*, 2011) and France (Payne *et al.*, 2013). Disease in badgers is thought to be one important reason why TB has so far proven impossible to eradicate from cattle in parts of the UK, particularly the south-west of England.

With their distinctive black and white striped coats they are highly valued by British society, and a much-loved part of the wildlife fauna, but generally unloved by those involved in agriculture. Not everything is black and white when it comes to considering their role as carriers of disease. The badger's role in the spread of TB, and how to respond to that, has provoked fervent debate and 'ecological anxiety' (Robbins & Moore, 2012) in the UK. The role of badgers in the transmission of the disease is now regarded by most natural scientists involved in TB research as confirmed, but the angst-ridden question remains of 'What to do about the badger?', of which more will be said in Chapter 8.

Badgers are fairly ubiquitous in their presence across the lowland farm pastures of much of Britain and Ireland. They have been present for hundreds of years, and are classed as a native species in both GB (Roper, 2010) and Ireland (O'Meara *et al.*, 2012). Badgers and their setts are protected under The Wildlife (NI) Order 1985 as amended by the Wildlife and Natural Environment (NI) Act (2011), making it a criminal offence to kill badgers or disturb their habitat. Several farmers and private vets felt that badger numbers had increased markedly in NI because of the legal protections afforded them, with one vet providing his evidence as follows:

> 'I have been out at all times of the day and night calving cows and whatever over the last 35 years - it used to be that seeing a fox was a very rare event, and you never saw a badger - never ever. But two years ago I was out calving a cow about ten miles away, and on the way home at about three in the morning I saw three foxes and two badgers - live ones [*laughs*]. It is purely anecdotal, but it tends to show that there are a great deal more badgers than there used to be.' (Int A49, private vet)

A badger population survey conducted in 2007-2008 found that badgers were widespread across NI, and estimated the total population to be over 34,000, with 0.56 active main setts per km^2 (Reid *et al.*, 2011). Significantly, it found there was no significant difference in population compared with the previous survey conducted between 1990 and 1993. The survey findings do not match the strong perceptions of increasing badger (omni-) presence on the ground.

In contrast to their warm feelings towards cattle, badgers were not popular with the majority of farmers and vets. A few said that they liked them; most tolerated them as long as they had no TB; and a few had antipathy towards all of them:

> 'Well, what do badgers do for mankind? To be honest, I'm not a lover of badgers. The amount of calves they are putting down, and cattle going down, it doesn't compare to badgers. They have no regards for animals, cows are more, cows are my life, they're my friends like. Badgers seem to be the problem, and what do they do to mankind really? Badgers - they're only an animal - they're a certain amount of vermin too.' (Int A5, dairy farmer)

> 'What is a badger doing for the countryside? What is the argument for badgers, apart from "They're a lovely creature" [*with sarcasm*].' (Int A38, beef farmer)

Due to their nocturnal lifestyle, badgers are rarely seen during the daylight hours. They are most often seen dead, killed by road vehicles on country roads. Scientists have tracked their presence using cameras in cattle sheds and feed stores (Tolhurst *et al.*, 2009); followed their footprints in farmyards (Sleeman *et al.*, 2008); and recorded badger-cow meetings using radio frequency data loggers (Böhm *et al.*, 2008; Drewe *et al.*, 2013). Most of the time they go about their badger business unnoticed and without fanfare, dwelling underground, submerged and silent, out of view. When asked whether they had seen badgers on their farm, most farmers replied in the affirmative. On further questioning, most qualified this to suggest that they had seen *evidences* of their presence and activity, rather than actual *bodily* presences:

> 'The badgers ... I know when the cow pats dry out they turn them over and eat the grubs and all in below ... We know they are there - we never see them, but we know they are there because they're digging ...' (Int A14, beef farmer)

Trails of overturned cow pats provide evidence, but in a Northern Irish survey of badger setts and activity, a proportion of farmers were completely unaware of the badgers living in setts on their farm (Menzies *et al*., 2011). As Harman (2011: 37) points out with respect to objects: 'For the most part, objects withdraw into a shadowy subterranean realm that supports our conscious activity while seldom erupting into view'.

The majority of farmers were content to have wildlife species, including badgers, on their farm land. But their attitude towards the badger, and awareness of presence, could markedly change when TB struck the farmer's cattle:

> 'Well, it's easy for me saying in my situation here that I don't see a big problem with the badgers, but as I mentioned earlier there the badgers round here must be TB-free. I'm absolutely sure that badgers spread TB, but if the badgers aren't infected then they won't spread it.' (Int A22, dairy farmer)

In this sense, badgers become visible when they 'malfunction' (Harman, 2002: 18). This raised awareness is recognised as a reporting bias in road-traffic accident (RTA) surveys of badgers for *M. bovis* (Krebs, 1997), where farmers with TB in their herds are more likely to report badgers found dead near their farm, keen to have them tested and shown to be the culprits for introducing TB to their herd. The 'outbreak narrative' of the 'contagious' (Wald, 2008) badger is a very powerful one, with the following quotes typical of prevailing views:

> 'I think they do have a role to play. I have experience of badgers causing it on our own farm. We had one animal during the summertime - it was a

bull and it was inside and the badger came in and ate the bull's food at night. The door was open to be ready for cows coming in the next morning, and the cows didn't have TB but this one bull did have TB, and everything else was clear ... One night dad went down to check a cow and he saw the badger heading out [of the shed].' (Int A59, private vet)

PR: 'So why do you think we haven't been able to eradicate TB?'

[*6 second pause*] 'I think the badger's definitely the culprit. They're dirty animals ... they poke through the field, they dung everywhere, they're messy things, they make an awful mess.' (Int A6, dairy farmer)

'No matter how much testing of the cattle that you do to try to eradicate it, they are still being re-infected from the wildlife [badgers], and I suppose I would liken it to when our kids were at primary school - there were a couple of kids in the school who had head lice, and it didn't matter how often my wife checked their hair and cleaned their hair and did all the stuff with their hair - they still went back in and sat beside wee Johnny the next day, and were as bad again in a week.' (Int A52, private vet)

Badger mobilities were viewed as being responsible for the carriage of TB from one farm to another, with badgers appearing to move silently across boundaries which offered no resistance to their passage:

PR: 'What about between-herd transmission? Do you tend to find...you must do LCTs - these are set up by DARD vets to try and find between-herd transmission - do you rate that as important?'

'No, not so much. It seems to be that you could have two beasts down in a herd and everyone else in a circle around him clear. I blame that on the movement of the badger between herds - I don't blame it on cattle-to-cattle transmission over the hedge. It's badger movements between ... A badger on one farm does not stick to that one farm - he doesn't see the boundaries you know.' (Int A17, private vet)

'It apparently started up behind [local area] ... and this area seemed to be relatively clear, but then we all got the notion that those were the naughty badgers with the TB, and the good badgers were down this way. And then the badgers have started to move across the hill ...' (Int A30, dairy farmer)

In common with other 'pestilence discourses' (Knight, 2000), badgers are often seen by farmers as 'dirty', with 'dirty' badgers seen as diseased, and 'clean' badgers as disease-free. 'Scapegoating' has a long history in disease explanation (Hinchliffe *et al.*, 2013), and 'dirty' badger is a discourse that stretches back a long way. As Cassidy (2012) shows, such framings are seen in historical literatures in addition to the discourses of the modern day, particularly in relation to badgers as carriers of disease. This fits with Douglas' (1966:35) observation that 'our idea of dirt is dominated by the knowledge of pathogenic organisms' and that 'dirt is matter out of place'. In the badger TB discourse, 'clean' badgers were a solace for farmers, and to be retained on the farm, with ill-feeling directed only towards out-of-place 'dirty' badgers with the potential to infect cattle in the locality. Using Douglas' (1966) framing of pollution and taboo, there are 'pure' badgers and 'dangerous' badgers.

Rather than the encounters with 'cosy' companion species (Haraway, 2003), what does it mean then to have encounters with 'other' creatures such as badgers which are viewed by farmers as nasty or perhaps repulsive? Slugs (Ginn, 2013), feral dogs (Srinivasan, 2013), wolves (Buller, 2008) or even cougars (Collard, 2012) – all can be described as 'significant others' (Haraway, 2003). Conversely, Haraway (2003: 15) suggests that 'companion species' include objects like 'rice, bees, tulips, and intestinal flora ...' *Clean* badgers could be added to this list of companions when they become the farmer's ally in keeping out *dirty* badgers. Now the badger becomes a companion species: clean-badger is welcome in cow-space. Indeed these clean-badgers were seen as a buttress against the influx of 'dirty' badgers due to their territorial behaviour. In this 'ironic reversal' (Haraway, 2003: 22), clean-badger becomes friend of the farmer in alliance against dirty-badger, would-be invader of clean space and agent of disease:

> 'I was told back in the 1970s if you have badgers on the farm, and no bother with TB, never do them in, because they are clean badgers, and I think that's right. There are clean badgers and dirty badgers, and we never have any problem with TB now ... We never touch the badgers.' (Int A12, dairy and beef farmer)

> 'I think there's a lot to be said on that story about clean badgers - if you have clean badgers they do seem to keep the dirty ones out, and I would definitely believe that.' (Int A59, private vet)

> 'But, while I have no TB, I am quite happy to let those badgers stay there, but you could tell me better than I could tell you, but I have heard that if you have healthy badgers you should let them stay, because if you do anything on them - which is illegal anyway, but there's things done - but if you do anything on them, then other ones will spread into that area, and if they have got it, you have just run yourself into a problem.' (Int A9, dairy farmer)

Badgers can be thought of as 'invaders' or 'aliens', trespassing into cow fields and sheds, a pest to be eradicated and barred entry into cow-space. Rather than feral cats in an 'ordered urban space' (Griffiths *et al.*, 2000), we have other 'wild things' in an ordered agricultural space. Yet the badgers cannot be accurately classed as 'invaders' in the biological sense of the word, for biological invasion occurs 'when an organism, any sort of organism, arrives somewhere beyond its previous range' (Williamson, 1996:1). Although most individual badger mobilities are within a 3 km radius, a recent study found that badgers sometimes moved much further away from their home territories than was previously thought, with long-distance movements of up to 22 km recorded (Byrne *et al.*, 2014). For the most part, badgers stay within their usual range, circulating where they always have, but their disease status as infected and potential spreaders of disease make them 'animals out of place' (Knight, 2000: 14). What is environmentally ironic (Atkins *et al.*, 2007) is that the lush and well-managed grassland pastures of the dairy and beef industries provide 'a fertile soil, a good soup, for the development of insects, bacteria, germs … [and particularly badgers]' (Deleuze & Guattari, 1987:69). Cow habitat is very suitable as badger habitat, and badger surveys in NI have shown that the two are closely aligned in the landscape (Reid *et al.*, 2011).

Although badgers are regarded as the main problem, they are not the only wildlife species being implicated in TB breakdowns - feral deer were also discussed as vectors of the disease in some parts of NI and elsewhere in the UK:

> 'We have one herd where we know that deer are a big factor … It is a closed dairy herd; they buy in nothing. What they do have is a large population of feral deer … [They] shot a lot of deer … and they were

> riddled [with TB] … They cleared out all the feral deer that they had … and they haven't had a problem since.' (Int A40, private vet)

> 'Last year we had … breakdowns in an area near a forest … there was only one deer that happened to be killed, and it was riddled with TB … the problem has started again … but that's a combination of badgers and deer …' (Int A43, state vet)

Whether deer are significant in NI is uncertain, but they have certainly been recognised as infected and potentially problematic reservoirs of *M. bovis* infection in other parts of the world, for example Michigan (Schmitt *et al.*, 2002) and France (Zanella *et al.*, 2008). A survey of TB in deer in NI in 2008-2009 found just 2% of 146 deer to be positive for *M. bovis* (DARD, n.d.), and Ward *et al.* (2008) postulated that deer were less likely to be a risk to cattle populations than badgers in south-west England. Given that O'Hagan *et al.* (2013) reported that 29.1% of farms with TB reported seeing wild deer on their land in Co. Down, and 22.7% of farms without TB (no significant difference), the overall significance of their role in the epidemiology of TB remains questionable, but merits further investigation.

Bacterium – forgotten materiality

Following on from these considerations of land, bovine mobilities, and wildlife, this section focuses on the social relations and infectious ecologies of the bacterium which ultimately causes the disease within this pathogenic landscape. The scientific literature has a lot to say about *Mycobacterium bovis*, and this section will bring some of this science into view. Vets, and especially farmers, found it difficult to speak about the bacterium, and it was rarely mentioned without prompts. In some sense it was a forgotten and invisible actor within the landscape, but perhaps a 'more-than-human' geography was an ontological and epistemological step too far. Those who did speak could more readily do so when it was discussed using militaristic framings as a battle against a potentially deadly enemy. Whilst derogatory and combative language was used to describe its performances, there was an admiration amongst vets for its resilience and adaptability as a pathogen. *M. bovis* may be social, but its relations are not widely discussed within the landscapes of TB in the field.

To use the word 'social' in connection with a bacterium is not as strange as it first appears - natural scientists recognize that bacteria and other microorganisms are 'social' beings (Brown & Buckling, 2008) with communication skills (Federle & Bassler, 2003). Different strains of *M. bovis* circulate within the landscape, and their cartographies can be elucidated through molecular typing methodologies in the laboratory. Some strain types are found far from their normal home range, presumably diffused through bovine mobilities, and yet more sources of infection are local (Skuce *et al.,* 2010). Genetically identical strains are shared between cattle and badgers in the same locality strongly suggesting sharing of microbes in sympatric populations of the two species (Biek *et al.*, 2012). The relations of the bacterium are multi-scalar and multi-sited – ranging from encounters between and within animal bodies to survival in the environment in soil and other material, particularly excretions from infected animals. To borrow Longhurst's (2001: 1) concept of messy fluidity, this is the stuff of 'leaks, flows and filtrations that occur across … bodily [and other] boundaries'.

Contrary to Heidegger's views on non-human things, as a living biological and 'social' organism *M. bovis* may indeed have *Dasein (*'being-in-the-world') (Heidegger, 1962: 78-107), with a 'vital materiality' (Gregson *et al.*, 2010). It illustrates Shaw's (2012: 613) assertion that objects have power to affect as 'smouldering furnaces of affects that are capable of creating, policing, and destroying the very contours of existence'. Whilst not ascribing *intentional* agency to the bacterium, it has an agency which is perhaps akin to the 'small agency' of Darwin's observations on earthworms: 'Darwin describes the activities of worms as one of many "small agencies" whose accumulated effects turn out to be quite big' (Bennett, 2010: 96). Maybe it is 'poor in world' rather than 'world-less' or 'world-forming' (Heidegger, 1995: 184).

Like the water voles in inner-city Birmingham, leaving only footprints to betray their presence (Hinchliffe, 2007: 144), and the badgers already discussed, *M. bovis* remains largely unseen and difficult to detect. As considered in Chapter 6, it can evade the vet's tuberculin test which looks for its immunological footprints, shown by swellings in the skin at the tuberculin injection sites. Only after death is its being more definitively confirmed. The carcasses are opened, and the search begins for the tell-tale abscesses (lesions) usually found in the lungs and associated lymph glands – like 'clusters of grapes' in the very advanced cases seen historically - confirm the results of the positive tuberculin test. Pinprick lesions are detected under the microscope, and the bacteria multiply (very slowly) on agar culture plates in the laboratory. Special broths are required to encourage its growth. It remains elusive even when it is isolated and cultured: it is a slippery and indeterminate microorganism.

M. bovis has presence in the material 'stuff' in which it mobilizes and has its being *outside* of the cattle who are the primary hosts of the bacterium – particularly in dung, nasal secretions, milk and water droplets. Dung or 'slurry' as it is usually known in the industry, is an animal waste product, the bodily excretion of undigested foodstuffs. Infected animals excrete *M. bovis* in the dung, mainly due to bacilli from lesions in the lung being swept up the windpipe in mucus and then swallowed. Schroeder and Cotton (1907) estimated that one diseased cow could excrete 38 million tubercle bacilli per day through 13 kg of dung. Scanlon and Quinn (2000) suggested that *M. bovis* organisms may survive for up to six months in slurry. Nasal secretions from infected animals have also been found to contain *M. bovis* (de Kantor & Roswurm, 1978), and these mucus secretions are thought to contain the organisms from three months after initial infection (Neill *et al.*, 1991), when the animal begins to excrete the bacteria. As far back as the last quarter of the 19^{th} century it was recognized that the bacteria are also excreted in milk, if the diseased animal happens to have infection in the udder (Pritchard, 1988). Zanini *et al.* (1998) state that 'a typically infected udder may excrete tubercle bacteria to the extent of 5×10^2 - 5×10^5 per ml of milk'. Slurry ingestion is thought to be a rare source of infection in cattle (Menzies & Neill, 2000), but nasal secretions shared through close bodily encounters may be more important (Neill *et al.*, 1989; Cassidy *et al.*, 1999).

The most significant aspect of *M. bovis'* mobility is its flight through the air in minute watery droplets of respiratory fluid, aerosols coughed up in expulsions from the lungs. Just like the asbestos fibres which are disturbed and released in demolition work producing 'an airborne dance of inextinguishable fibres' (Gregson *et al.*, 2010: 1067), so these violent eruptions from the bovine lung release *M. bovis* in its most potent form. Inhalation of these droplets in the air is the most common form of transmission of infection between cattle (Pollock & Neill, 2002), and is also postulated to be the main route of transmission between badgers, and between badgers and cattle (Corner *et al.*, 2011). Gannon *et al.* (2007) demonstrated in a laboratory study that *M. bovis* is robust in its airborne state, with 94% of bacilli surviving the first ten minutes after aerosolisation, and they concluded that once airborne it can survive for prolonged periods. Such is the potency of *M. bovis* that only one colony-forming-unit (CFU), containing between six and ten viable bacilli, is required to initiate successful respiratory infection (Dean *et al.*, 2005). Many more bacilli are necessary to initiate infection through ingestion (Menzies & Neill, 2000). Vets agreed that respiratory transmission between cattle was the more likely route:

> 'If it's respiratory lesions found mainly in the abattoir it has to be cattle-to-cattle transmission by breathing. It has to be breathed. They are reasonably gregarious animals, and they are bound to breathe it to each other.' (Int A19, private vet)

Rather than the gas warfare of World War I of which Sloterdijk speaks, this particular 'terror from the air' also causes the air to 'lose its innocence' (Sloterdijk, 2009: 109). Like the prions of mad cow disease (BSE), 'an insidious, invisible enemy is amongst us' (Callon *et al.*, 2011: 1), but as discussed in Chapter 5, the unpredictable and heterogeneous presences of TB raise questions about how exactly the microbe mobilises between animals, and conversely, why it does not:

> PR: 'How do you think it spreads between cattle?'
>
> 'Well again I have no idea, because there are so many cattle it doesn't spread to - what is stopping them from taking it? Why do they not take it?' (Int A21, beef farmer)

The key point is that the bacterium in its mobile state outside of an animal is of no particular significance in and of itself – it is doing no harm, it is merely a rod-shaped bacterium with *potential* agency. Napier's (2012: 127) discussion of viruses is relevant here: 'If, on its own, a virus remains inert and without locomotion, why should we privilege it with agency?' All infected bovine materiality becomes subject to the legislative control of the state: restrictions can be placed on slurry and where it can be spread; animal accommodation and facilities must be cleansed and disinfected; animals are isolated to prevent contact with others; milk is discarded from infected animals. But to adopt true significance and being, to exert its most important effects from its various mobilities, the organisms must be ingested or inhaled by another animal. The rod-shaped bacterium morphs into a silent killer, for it does indeed have a 'colonising materiality' (Gregson 2012: 2016). As state vets explained, *M. bovis* could certainly be described as opportunistic:

> ‘It takes every possible opportunity to spread to other species and to get itself a little niche … It seems perfectly adaptable to any situation. If it was a war situation with a live enemy it would be laughing at us.’ (Int A41, state vet)

> ‘It has such a wide host range, and the fact that some of those can play a role – [particularly] badgers and deer. The fact that it infects such a wide range of tissues means that you have got several routes of infection and excretion. You've got the respiratory route, the oral route … You've got the milk; you've got uterine discharges; you have a lot of options there …’ (Int A42, state vet)

Perhaps the greatest success of *M. bovis* rests in its ability to often resist the immune responses, and to reach an entente cordiale with the host animal within the macrophage – a microbial ‘politics of conviviality’ (Hinchliffe & Whatmore, 2006) and a dwelling safe within the very immune cells sent to exterminate it – an irony indeed. The infected macrophage becomes the centre of a lesion – a ‘granuloma’ - a cheesy abscess of dead and gradually decaying matter surrounding a bacterium which can remain very much alive, and with the ability to recrudesce months or even years later. Subsequent infections with other mycobacteria have been found to ‘home in’ on the existing granuloma, showing that they are permeable entities with fluid borders. These mycobacterial transit hubs do not offer protection to the host from future invaders (Cosma *et al.*, 2008). The mycobacteria often appear content to bide their time until exerting their destructive effects, waiting for the opportune moment to reactivate when defences are weakened through old age or a compromised immune system. Weakened immunity in the host, for whatever reason, may play a part if allowing *M. bovis* to exercise its mobile and destructive agencies:

> ‘If you have a situation where *M. bovis* is ticking over and maybe not causing disease … if you have the organism sitting in the lung, or sitting in the nasal cavity, or sitting in the tonsil, not doing anything - just surviving, ticking over … Is it feasible that you … have another agent [coming] in there, an immunosuppressive agent, and these animals that normally would just have been ticking over have suddenly succumbed to the infection?’ (Int A33, research scientist)

> 'If it can manage to stay in an animal and wall itself off, the nasty little sod can stay out of the way, without detection by our TB test, and then eventually at some point in time it can break out again and cause more infection to other animals. So it's a clever little sod.' (Int A40, private vet)

Breakdown of the granuloma and bacterial mobilities within the body mean that new lesions can be formed and the healthy lung tissue (or whatever organ is seeded with infection) is destroyed – a slow, chronic, insidious process, but one which is very seldom seen in the developed world where regular animal testing removes infected animals before death would occur by natural course.

'Materials continually have the capacity to surprise humans' declare Gregson *et al.* (2010: 1081), and they remind us that 'these surprises can be less than enchanting, nasty and certainly costly'. Much the same can be said of *M. bovis*; the bacterium is uncooperative (Atkins & Robinson, 2013a), and has a capacity to surprise. The material and corporeal presences of the organism are varied and diffuse, but the transmission performances of the bacterium are perhaps most surprising of all. Conflicting and confusing both vets and farmers, the bacterium can 'hide' in the nasal cavity seemingly doing nothing; or move slowly and hesitatingly to affect one or two animals; or rapidly mobilizing to devastate populations:

> 'There were animals that didn't show any signs of TB [on the TB test], and yet they had *M. bovis* up their noses. How do you explain that? It brought back "What is meant by infection?"' (Int A33, research scientist)
>
> 'I think the only thing that saves us from wildfire spread of disease throughout the whole blooming country is the fact that TB actually does not transmit that easily and readily between bovines - it happens, but if it were to happen at the same rate as some other diseases, we would be over-run ... There must also be animals that have generalised TB - and I'm talking bovines here - that are spewing out a lot of bacteria, and every now and again you hit the jackpot and you get 30, 50, 100 [reactors].' (Int A42, state vet)

Perhaps fortuitously for the bacterium, the spotlight shines particularly strongly on the agency of the badger, and its own agency remains obscured from view:

> 'It's a bit disheartening as a young vet trying to test these animals to get them clear of diseases, and yet there's a dirty old animal [the badger] running about infecting everything.' (Int A17, private vet)

Attention is deflected, and rather than the bovines of which Callon speaks, the 'peaceable [badger] is suddenly transformed into a dangerous political animal that everyone should be wary of' (Callon *et al.,* 2011: 1). While the focus remains firmly fixed on the badger, the bacterium tends to remain backstage and out of the limelight. Perhaps therefore the bacterium is the real 'other', moreover the *forgotten* other, in all of this complex and mysterious political ecology of disease. *M. bovis,* readily crossing between farms and species, patently has a 'microbial indifference to boundaries' (Wald, 2008: 33). To adapt Manson's (1998: 37) theorizing on malaria and the mosquito, perhaps *M. bovis* is the real 'beast' in the badger. That makes the badger an unwitting Trojan horse, and the cow an innocent victim. More research is required on transmission pathways and the directionality of *M. bovis'* mobilities between badgers and cattle. Not everything, after all, is black and white in this landscape assemblage.

Considering a pathogenic landscape

Considering the pathogenic landscape of TB has proven useful to investigating the ecologies of this disease. Advocating a new direction for future research in the political ecology of health, King and Crews (2013: 283-284) explicitly encourage research on disease *landscapes*, including analysis of land use and land cover and the mobilities of microbes (and in their scholarship, people) across boundaries. The role of farmers has been important in my analysis, for 'landscapes rarely materialize without human input' (Gezon, 2006: 15) because of the dialectical relationship between them (Batterbury, 2001). Farmers and their everyday farming practices weave through the narrative.

The ecologies of TB described in this chapter both within and between animal bodies, across pastures and over fences, make TB particularly difficult to govern.

The practices and patterns of cattle trading and land management are deeply embedded in the cultures and psyches of NI farmers, and are underpinned by the political economies of modern intensive agriculture. Although the state seeks to regulate bovines through statutory notification of their movements between herds, there are plenty of unregulated movements within farm holdings over which they have no control. Opportunities abound for cattle to meet other cattle on their journeys through markets and as they move into new areas within fragmented farm holdings, meeting neighbouring cattle herds across field boundaries. It is also difficult to keep badgers and cattle apart in farm space, although even this is complicated by the benefits of keeping 'clean' badgers on TB-free farms. Lastly, the bacterium itself has unruly and unpredictable characteristics.

This chapter has shown therefore that understanding this pathogenic landscape means understanding the 'matter of nature' (Bakker & Bridge, 2006), and unpacking this material and 'more-than-human' (Whatmore, 2002) assemblage is the key to understanding why TB continues to circulate within cattle populations in NI. These circulatory flows are material and constant; the leaks are fluid and unpredictable; the landscape is in a state of continual flux, being made and re-made on a daily basis through the complex ecologies of TB. Law (2006: 236), speaking of the spread of FMD virus, concluded that 'we are dealing not with one flow, the flow of a virus, but a pattern, a web, of partially connected and different flows with criss-crossing barriers, and it is the intersection of these different flows and their levees that produces the potential for leaks'. Bacteria, badgers, deer and cattle mobilize through the landscape, contacting and colliding with one another in seemingly random and heterogeneous patterns to spread the disease in time and space; TB produces infected places. In the fluid spaces where leaks occur (Mol & Law, 1994) there are multiple opportunities for species to ‘meet and mingle’ (Greenhough, 2012). These mobilities all facilitate the spread of this disease, and the risks are challenging to control. Nonetheless, Chapter 8 will demonstrate that governing TB towards eradication is about more than containing the lively ecologies of the disease, although these are obviously an integral part; there are also other frictions and slippages to deal with.

Chapter 8: Governance of more than a disease

'Then I witnessed the torture of Sisyphus, as he wrestled with a huge rock with both hands. Bracing himself and thrusting with hands and feet he pushed the boulder uphill to the top. But every time, as he was about to send it toppling over the crest, its sheer weight turned it back, and once again towards the plain the pitiless rock rolled down. So once more he had to wrestle with the thing and push it up, while the sweat poured from his limbs and the dust rose high above his head.'

(Homer, 1946: 155)

Sisyphus sought to govern the boulder, but despite his most strenuous efforts, the 'pitiless rock' mastered *him*, rather than the reverse. Just like the boulder in Homer's Greek epic, TB has proven tortuously difficult to govern, and has involved the shedding of much sweat and generated much frustration over many years. Mastering this disease to the point of eradication has proven thus far to be elusive, and beyond possession. It was not meant to be so. As described in Chapter 3, the advent of the eradication programme brought early success, and hope sprang eternal that eradication was just over the horizon. Then, as now, the chief aim was to protect the ability to trade animals and animal products. The European Council Directive 64/432/EEC (EEC, 1964) introduced rules governing intra-Community trade in cattle to specify the health conditions facilitating such trade without risk of spreading diseases such as TB. This legislation still governs the export trade which the state seeks to protect at all costs.

But protecting trade was not the only aim in the Community enacting legislation concerning TB. Thirteen years later, European Directive 77/391/EEC required that 'Member States in which the cattle populations are infected with bovine tuberculosis shall draw up plans for accelerating the eradication of this disease in their national territories' (EEC, 1977: 45). Eradication has therefore long been the EU's target for the governance of TB; merely containing the disease is not on the European agenda.

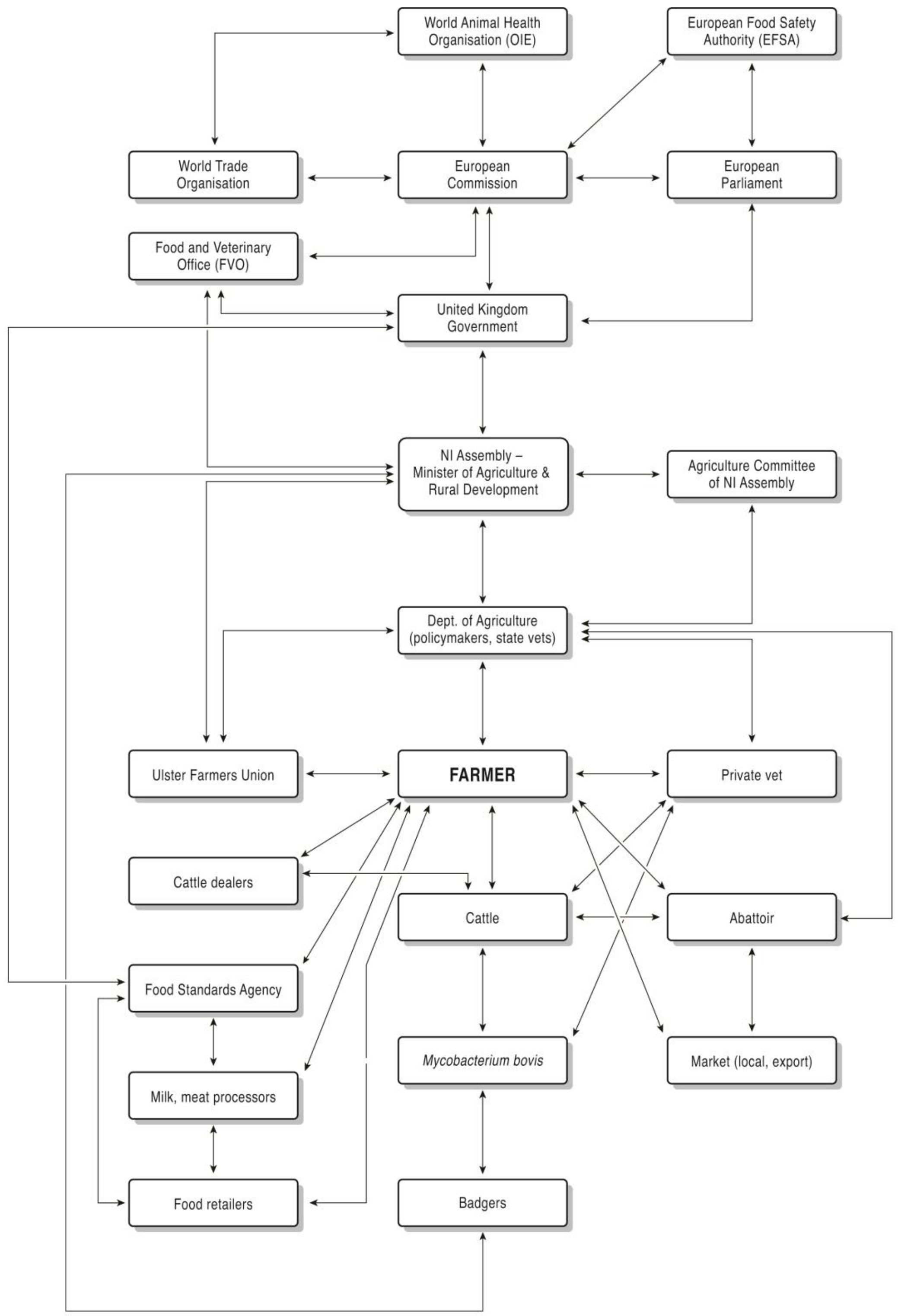
If what Walker (2006: 385) states is true, then 'the most fundamental role of political ecology is to question the oversimplifying and misleading conventional views of human-environment relations'. For TB, at least in the UK and ROI, eradication is no simple matter. It is not merely a case of implementing a test and slaughter policy for cattle, because simple statements in European legislative documents become messy complexities on the front line of policy implementation and governance, as will be amply demonstrated through the interview data presented in this chapter.

Just as 'both nature and the human factor intervened' to spoil utopian dreams of the perfect, scientifically-ordered forest (Scott, 1998: 19), so both natural and social factors have intervened to foil disease eradication objectives. To move towards a point where eradication may be achieved, or at least to move ever closer to that point, requires and enlists the exercise of governance at multiple scales and across multiple actors, both human and non-human (see Figure 10 for schematic outline of relationships).

Governance refers to 'how organisation, decisions, order and rule are achieved in heterogeneous and highly differentiated societies' (Bridge & Perreault, 2009: 476). By including the material and non-human in models of *environmental* governance, this increases the heterogeneity and sociality to encompass problematics of scale, politics, resource management, state regulation and the production of socio-natural order (Bridge & Perreault, 2009). The operation of power in this assemblage is not on discrete levels or planes – instead, it is messy and diffuse, just like the spread of the disease.

This chapter therefore seeks to explore the points of friction, slippages, cracks, messiness, and overflows in a 'hot' situation (Callon, 1998). The aim is to 'lay bare the power geometries, and interrogate their origins and implications' (Bridge & Perreault, 2009: 492). It unpicks the governance of farmers, vets, badgers, bovines, bacteria and the state to prove that governing TB is about more than governing a disease. It begins by looking at how the state seeks to govern farmers; and how farmers in turn often have a tendency to resist until coerced.

Figure 10: The TB governance network in NI



Governing farmers

Farmers are enrolled in TB governance because the law of the land requires them to present their cattle for TB testing when required to do so by the state. They are also obligated to surrender positive animals to the state for compulsory slaughter. In return, they receive monetary compensation to the market value of the animal, and in 2012-13 this compensation cost the state £16.2M from a total state expenditure of £30.9M on TB control in NI (DARD, unpublished).

Political scientist Wyn Grant (2012: 271) considers that 'agricultural policy is an area characterized by intensive interaction between farmers and government'. What often characterizes these state-farmer interactions in relation to TB are frictions and acrimonies. The majority of the interactions are micro-level encounters between individual farmers and local state veterinary officials on the ground. Most of the time this maintains general order and acquiescence, but there is nevertheless often an underlying tension. The relationships between farmers and the state are often fragile, and whilst TB is certainly a 'matter of concern' (Latour, 2004), few farmers appear to be actively and enthusiastically engaged with the TB programme at ground level. We may have returned to the days when 'the leaders of agricultural interests are clamouring for action' (Pool, 1945: 82), but this may be met with apathy and disillusionment at the farm gate.

What is clear is that TB will not be eradicated if farmers are not an integral part of the eradication effort, partnering with the state to meet a shared objective. As mentioned in Chapter 4, experiences from other parts of the world and throughout history have consistently shown that farmers, if not in agreement or fully persuaded by the overall objectives, costs and methodologies of TB eradication programmes, will hinder and obstruct progress towards disease eradication (Pool, 1945; O'Connor, 1986; Moda, 2006; Waddington, 2004; Olmstead & Rhode, 2007; Fisher, 2013). Successful eradication, however, has engaged the farming industry and brought them on board to work in partnership with state authorities, as was demonstrated in the eradication of TB from Australia (Radunz, 2006). NZ has gone a step further in separating the TB eradication programme from the state, and instead creating an industry partnership through *TB-Free New Zealand*. The approach in NI remains state-led, governed by DARD officials and vets in a top-down structure under the authority of the Minister of Agriculture and Rural Development. While the programme may be primarily concerned with eradicating TB, this also involves controlling the farmers who manage the cattle that succumb to the disease. The evidence points to difficulties in the relationship between the farmer and the state. This is a common problem which Palmer's research in Australia demonstrated, with 'farmers … demanding that government take more responsibility for disease issues but at the same time resent[ing] government interference' (Palmer *et al.*, 2009: 371).

Pushing the boundaries

Vets, both state and private, expressed opinions which suggested that farmers in NI were difficult to govern, and that there was an intrinsic unruliness within the farming community. Various explanations were given. Three vets provided cultural comparisons to other parts of the UK, and suggested that farmers in NI were somehow different to their counterparts elsewhere:

> 'I think … they don't like being told what to do, and the entrepreneurial spirit comes out quite a lot. [Other vets] found that when you told farmers [in Scotland] to do something they did it, whereas over here it would be a struggle … There is a cultural divide there of some sort which is hard to define.' (Int A45, state vet)

> 'I think that most farmers here look at regulations as something you only comply with when you have to … There is a very different culture within the farming community here than there is anywhere else in the UK, I would say. There is certainly a different type of attitude.' (Int A48, private vet)

> 'The other thing is that in England, Scotland and Wales the farming community are all reasonably law-abiding [*laughs*], but there is an element within Ireland - both north and south: "Oh well, a little bit of nefarious activity doesn't do anybody any harm." And the idea that they can get one over on the government is much more prevalent in society here than it is in England, and you're *never* going to get over that one. There is that attitude, that you can do something slightly illegal.' (Int A49, private vet)

One vet thought that farmers' independence made them resistant to any kind of 'interference' in their farming lives, and that they did not appreciate being told what to do by anyone, particularly the state. The most common response in answer to what they liked about being a farmer was 'being their own boss', although this freedom was said to be tempered by state regulation which had eroded their liberty. If this independent spirit was descriptive of many farmers, one argued it had a definite downside: 'We were just talking to neighbours today and that's what we were saying is wrong with farmers in NI - they don't stick together, to be as strong as a body' (Int A3, dairy farmer). Whilst the UFU in NI may have approximately 12,500 members, farmers lacked faith in the representative structures of farming to influence change in agricultural policy for their collective good. A cattle industry dominated by individualistic approaches has implications for the governance of endemic disease control (Wilkinson *et al.*, 2011).

A state vet suggested that attitudes towards DARD had changed over the years, and linked the failure to eradicate TB to a hardening of attitudes towards compliance with the control programme:

> 'It's a different world out there - people are not as open to being told exactly what to do and when to do it and how to do it. The farming community is much better educated. They understand these things, they understand when things are working, and they understand when things are not working.' (Int A41, state vet)

Farmers themselves acknowledged this tendency towards resistance, best described as ‘boundary pushing’, which several acknowledged harmed the image of the farming community in the eyes of both the state and the wider public:

> PR: ‘Do you think farmers try to push the boundaries?’
>
> ‘In some cases very much so, yes. Farmers can be their own worst enemies.’
>
> PR: ‘Do you think that spoils it for everybody else?’
>
> ‘Well, we all get tarred then with the same stick - no doubt about it.’ (Int A29, dairy farmer)

If farmers were tarnished by the image produced by the law-breakers in their midst, farmers also argued that DARD was a ‘necessary evil’ (Int A4, dairy farmer) to police and correct such malfeasance, and this farmer explained his reasoning:

> ‘Well, it's necessary because if they weren't there, farmers would do what they liked basically, so you need somebody there to keep things in check and to police things because I know, and you know, that farmers generally like to get away with whatever they think they can - they push the boundaries. So I think from that point of view DARD need to be there, and need to be policing the thing. I think sometimes they pick the easy targets, and they will not go to places they should be going to.’ (Int A4, dairy farmer)

Along with the admission of boundary-pushing therefore came this acute sense of fairness and social justice - those who broke the law should be punished and brought under the discipline of the state, with no place to hide. This conflicted position underlined the tension between fervent cries for relief from the heavy burden of EU and national regulation, set against a desire to see those who stepped over the line being brought under control. One farmer judicially declared: ‘Let the full rigour of the law fall upon [them]’ (Int A50, dairy farmer).

State vets described the effects of farmers breaking the law with respect to TB legislation and hindering the efficient functioning of the programme. The problem is certainly not unique to NI, and writing in relation to TB in the ROI, O'Connor (1986: 65) wrote of a similar scenario:

'Most herd owners do their best to obey the rules, but there are many others, some well-known to the authorities, who flout the rules continually, either through carelessness, design, or ignorance and are mainly responsible for spreading the disease to clean herds.'

Rather than higher level crimes such as deliberate interference with the TB skin test and forms of serious financial fraud, the greatest effect on the programme's overall success was thought to be from the significantly more frequent low-level misdemeanours and bending of the rules: 'The insidious undermining of controls' (Int A61, state vet). For example, this interchange between state vets described typical behaviour in anticipation of an impending and overdue TB test:

> Vet 2: 'You give them an extra month on it and they're trying to sell everything before they test, and it's just too lackadaisical.'
>
> Vet 3: 'That's a big problem here. People say to me – "No, I don't want to test - I want to get rid of all ..." And you think "Whao!" [*laughs*] "I want to get rid of as much as possible in case I'm closed down."' //
>
> Vet 1: 'That's true. That's the thing.'
>
> Vet 3: // 'So they just offload all their problems onto someone else.' (Int A43, state vet focus group)

Mixing lower-level criminal activity with an avoidance of best practice, other offences and tactics included trying to avoid lateral check tests (LCTs) when neighbouring herds were found to have TB breakdowns; swapping the identification ear tags of cattle; not isolating inconclusive or reactor animals; sharing bulls between herds without movement notification; and overall a lack of attention to farm biosecurity. Added to the large volume of legally notified cattle movements between farms are these 'under-the-radar' moves which circumvent the system and frustrate efforts to trace disease pathways:

> 'Our cattle control measures are not being implemented properly I don't think. We have movement controls in place which farmers are supposed to adhere to, but we well know that animals move from herd to herd that we don't know about.' (Int A45, state vet)

Overall, the cumulative effect of these unseen circumventions and resistances against the system of control were thought to greatly outweigh the 'headline' offenders who are brought before the courts:

> 'I wouldn't think those individuals do much damage overall to the industry, I think it's the middle section that do most damage. The middle section is the people who don't think it's [things that are] all that bad - it's just wee things: "I'll move an animal, but I'll not do a [brucellosis] pre-movement test. I'll do a wee workaround" ... Or you get a breakdown, and he says, "No, they haven't been out." And he knows fine well that he had them out at a field five miles away at conacre, but he never says so, because he doesn't want to get his neighbour into trouble - he doesn't want him to have to test. And we're not going to find out for about six months until we do his test.' (Int A61, state vet)

> 'Obviously there are the more significant things - the fraud potential. You definitely have people who are fraudulent and that can contribute to disease control, but I would hope that the level of that is low, and getting lower ... I would say the bulk of it is low-level type misdemeanours.' (Int A56, state vet)

Michel de Certeau (1984: xiv) describes the 'tactics' of those who resist and evade discipline in these terms: 'If it is true that the grid of "discipline" is everywhere becoming clearer and more extensive, it is all the more urgent to discover how an entire society resists being reduced to it ... [how they] manipulate the mechanisms of discipline and conform to them only in order to evade them.' If order means eradicating TB through the disciplining of farmers, then James C. Scott's (1985) work amongst Malaysian peasant farmers, although obviously in a very different context, serves warning that governance can be frustrated by 'the insidious undermining of controls'. Scott (1985: xvi) posits that the 'everyday resistance', when summated over time and space, can very significantly disrupt the exercise of control:

‘Most forms of this struggle stop well short of outright collective defiance. Here I have in mind the ordinary weapons of relatively powerless groups: foot dragging, dissimulation, desertion, false compliance ... It is my guess that just such kinds of resistance are often the most significant and the most effective over the long run.’ The state vets thought similarly for TB – ‘the middle section’ of boundary-pushers perhaps does most damage in the long run.

Broken relationships

The cumulative result of tensions between farmers and the state are broken relationships, especially between farmers and DARD as a corporate entity, although it did appear to be more functional at individual farm level. State vets spoke of how they persuaded farmers to comply with regulations which did not immediately appeal using a form of ‘street-level bureaucracy’ (Lipsky, 1980):

> Vet 1: ‘It's a way of getting things done.’
>
> Vet 3: ‘Because it works. If you just say “No, you're not doing that” then you'll have argy-bargy and it wastes time. You might as well just ... it's amazing here how people really seem to respond to friendliness.’
>
> Vet 1: ‘They do, yes.’
>
> Vet 3: ‘Farmers really respond to niceness and friendliness.’
>
> Vet 1: ‘It takes a while. You have to talk them round sometimes, and talk to them, and talk to them.’ (Int A43, state vets focus group)

The approach seems to be working at the front line, as generally farmers felt that DARD veterinary field staff who visited the farm were ‘more than helpful’ (Int A53, beef farmer), and this supports the hypothesis of Palmer *et al.* (2009) that the accessibility and personal contact between farmers and state vets helps increase levels of trust. In contrast, there was a different attitude to DARD as a corporate body; ‘elusive’ (Int A32, dairy farmer) staff in DARD offices; and especially towards officials who worked in DARD headquarters, having previously been in the field, but now ‘brainwashed’ (Int A53, beef farmer), as described in

Chapter 4. The UFU official spoke of how farmers regularly contacted their offices with queries which they should have been directing to DARD officials because they were 'scared of the Department' (Int A54, UFU). A farmer's wife said she was careful about how she couched questions when addressing DARD officials in the local veterinary office as she thought farmers were 'treated more as a criminal' and that DARD was 'very anti [farmers]' (Int A32). DARD was described as a 'Police force' by several farmers:

> PR: You describe them [DARD] as the 'Agricultural Police Force' - why is that?
>
> 'Because that's all they do now. They are not there as an advisory service, they're not there to help you - they're out there to get as much of your Single Farm Payment clawed back off you as possible.' (Int A28, dairy farmer)
>
> Farmer 1: 'Somebody recently said that he preferred to see the Police in the yard rather than the Department.'
>
> Farmer 3: 'Yes, good point [*laughs*]'.
>
> Farmer 2: 'The Police would let you off with a caution or a £90 fine, you know - it won't be 3% [of subsidy payment].' (Int A58, farmer focus group)

This breakdown in relationships has implications for the TB programme, and a general impression that a partnership approach was not likely given the current situation and recent history. A dairy farmer (Int A58) mentioned how BSE ('mad cow disease') had been handled by DARD in the past (mostly in the period late-1990s to early 2000s), which to his mind had left a bitter and lasting legacy still affecting the present. Another suggested that 'normally when you talk to them [DARD] it's when you're getting grief about something ... that puts a lot of men off even wanting to talk to the Department people' (Int A38, beef farmer). Communication channels had closed on many fronts, and farmer-state co-operation appeared disjointed and fractured.

Disillusionment

If governance of farmers was difficult, and relationships were sometimes strained to breaking point, the general mood of farmers and their relationship and experiences of TB eradication efforts may help to explain why such a situation may have developed. As described in Chapter 4, which painted a picture of farming in NI in the 21st century, cattle farmers are coping with multiple pressures, particularly the vagaries of the weather and squeezed profit margins. TB is but one threat among many, varying in importance and priority according to an individual farm's risk of breakdown. The overall effect of a failure to eradicate TB was one of disillusionment and in some cases despair, when TB was a chronic and never-ceasing problem:

> 'You know, there are the same farmers who are still having the mass outbreaks of TB and you can understand for those families - they sort of go up and down on a three or four year cycle. You can imagine they feel helpless ... they just feel truthfully that no one has effectively helped them in their problem. And they have suffered through that for 25 years plus. Your heart does bleed for those families ... He's got to the stage where he's lost all belief in the system, and he is very fatalistic about it. Actually yesterday when I was talking to him he was visibly upset, and he just said to me "I've given up. I have given up. I have given up so much these cattle aren't mine - they're my sons. I don't want to have anything to do with cattle anymore."' (Int A40, private vet)

Private vets spoke of farmers whose 'spirit was out of them' (Int A19); were 'naturally pessimistic'; and 'even the ones who are quite positive thinking can't be seen to be too optimistic ... they are very defensive. They don't open up. They don't talk about how things really are' (Int A48). The sentiments were well expressed by a state vet in the focus group:

> 'At the moment they are just frustrated and fed-up, and they feel nobody really understands what they're going through, and nobody is really listening to them.' (Int A43, state vet)

Given this emotional landscape, motivating farmers to engage more constructively in the programme is therefore very difficult, and several vets suggested that a *quid pro quo* was necessary, with badger governance (through culling or vaccination) as the most important 'carrot' to convince farmers that DARD was seeking to help them by eradicating TB. One state vet put it like this: 'Unless we [DARD] are seen to be doing something on the badgers, we are going to get no co-operation from the farmers' (Int A41, state vet). This was also the most common response from farmers when asked about what needed to change to move the eradication programme forward; badger culling was the great hope for change, renewed interest and engagement.

Coercive instruments

A state vet reached an alternative conclusion, suggesting that farmers' lack of financial input into the programme meant they were dissociated from its aims and objectives:

> 'If you look at NZ, farmers pay a lot for TB control - our farmers get it free. They get very good compensation, so the only thing that hassles them is the test … If they are getting well enough compensated and it's not really affecting them financially too much - it might be making their life difficult, but if it's not making too much difference, and they're not bought into it i.e. they're not paying some of their own hard-earned cash into the system, then I don't think you're going to change their attitude.' (Int A47, state vet)

Farmer 'buy-in' was seen as the key to success in Australia (Tweddle & Livingstone, 1994; Radunz, 2006) and the hope for the future of TB governance in the ROI (More, 2007). Some state vets I interviewed believed that reduced compensation for TB reactors was the best way to govern unruliness in farmers. Along with the announcement that there were would be a new 'strategic partnership' between the government and the industry to eradicate TB came the announcement that from 1st January 2014 any herd keeper with a TB test overdue by more than one month would receive cross-compliance subsidy fines (DARD, 2013c). The crude instrument of financial penalty appears to produce the desired effect:

> PR: 'We talked about DARD and private vets and their roles in TB control. What about the farmers - can any blame be attached to them for the failure to eradicate TB?'
>
> [*Pause*]. 'I'm sure we have [*hesitant, laughs*]. I'm sure we have [*laughs*]. I'm trying to figure out ... We should probably comply, and we have been complying with the Department more rigorously than in the past, because the penalties are now in place if we don't.' (Int A50, dairy farmer)

Discussing a World Bank funding scheme for improving village infrastructure in Indonesia, Li (2005: 387) points out that 'rational actors who wish to access project funds will choose to conform to project rules'. In the same way, farmers who wish to maximise their European subsidy funding will comply with the TB 'project rules' because it is easy for the state to detect non-compliance using centralized electronic animal health databases. Adding financial penalty may force compliance, paradoxically at the cost of further alienating farmers from the goal of eradicating TB in *partnership* with the state. The state could equally argue that farmers have been 'unable to exercise the responsibility of freedom' (Li, 2005: 387), and that 'soft regulation' (Koutalakis *et al*., 2010) has not worked well with farmers (as admitted by farmers themselves) requiring the implementation of these more authoritarian and punitive forms of state discipline.

Animal disease governance is therefore about more than controlling animals or the disease itself; it is also about governing the people who own and manage them. The corollary of this is that the coercive power of the state and farmer resistance can feed off one another and spiral into ever-deepening mutual mistrust; sight of the disease gets lost somewhere in between. The rift is not just between farmers and the state, but also has developed between private vets and the state.

Governing vets

The state relies heavily on private vets to conduct the bulk of the annual TB testing of the 1.6 million cattle in NI, and has done so since the beginning of the programme in the 1950s. Despite the dependence on the private sector for programme delivery, questions have been raised by state authorities for many years concerning the quality of TB testing by private vets. As explained in Chapter 3, the rise in TB incidence in the mid-1970s was partly attributed to poor standards of testing. One memorandum contained the following, rather sardonic, statement: 'Some vets did not do measurements with the exactness that they should have' (PRONI AG/33/30-g, 1976:1). At a staff meeting later in 1976 a Department official emphasized the 'essential need for effective control of all staff' in relation to TB testing (PRONI AG/33/30-i, 1976: 3).

Forty years later, exactly the same issues remain the fulcrum for tension between private vets and the state about the governance of veterinary TB testing standards. A NI Assembly Public Accounts Committee Report on TB (PAC, 2009) reported concerns about testing by private vets, with the Committee believing that some vets were failing to meet the high standards required of them. Reporting in the same year, the NI Audit Office Report into TB stated that 'poor quality work by [private vets] increases the risks of disease spread and fundamentally undermines the Department's TB control and eradication programme', and the report demanded a higher level of supervision of vets during testing (NIAO, 2009: 36). Comparing private vets with 'in-house' vets, the DARD vets were found to be between 1.5 and 1.8 times more likely to classify a herd as a TB breakdown (NIAO, 2009: 35).

Three years later, testing standards and comparisons were once again raised in the NI Assembly's Agriculture and Rural Development Committee Review of TB (NI Assembly, 2012a), and this heard evidence from DARD officials that in-house

DARD vets were 1.6 (2009), 1.19 (2010) and 1.93 (2011) times more likely to find a non-negative animal than a private vet. The Deputy Chief Veterinary Officer stated that 'the fact that the odds ratio has gone up to 1·93 is a matter of concern, particularly as we had been so energetic in our efforts to manage the contractual relationship' (NI Assembly, 2012a: 83). Numbers and statistics were used to 'know' TB (Enticott, 2001), but this time to 'know' the *vets* who tested for TB. This is not novel, for more than a century ago Moore (1913: 86-87) believed that 'the men who apply tuberculin should be trained and competent or the results will be untrustworthy ... It is too sensitive a reagent to be trusted to the unskilled'.

Rather than being tacitly prepared to accept sub-standard testing, as suggested by Enticott (2014) for state veterinary authorities in GB, DARD vets were keen to adopt an active programme of surveillance not just on cattle, but also on vets themselves. That which had been rejected in 1976 as an affront to a fellow professional (PRONI AG/33/30-i, 1976) became a reality, but the transition was not always a smooth one, especially in the early days under new governance regimes:

> 'It's like us auditing the vets' testing performance - they hate it; they absolutely loathe it, because "We're a professional, why do you do it?" Well, [we] wouldn't if [we] didn't find anything, but the truth of the matter is that [we] find things which disturb.' (Int A61, state vet)

State vets, reinforcing or repeating the conclusions from the various inquiries into TB, generally had a poor impression of the standard of testing from their colleagues in the private sector. The following responses were typical when discussing the performance of the test and its perceived role in the ongoing spread of the disease:

> 'It would have to be an imperfect, arguably subjective test, which we know is carried out pretty poorly, and it causes us to miss a lot of breakdowns.' (Int A42, state vet)

PR: 'You mentioned about private vets not using calipers, and the Department has had a big push in recent years to inspect PVPs for testing and so on - do you think there is still bad testing out there from PVPs?'

Vet 4: 'Absolutely. '

Vet 2: 'Yeah, definitely.'

Vet 4: 'Without a doubt.'

Vet 3: 'You do find that.'

Vet 5: '… I think in the past you had the vet never coming back the second day to read the animals - we have progressed quite a lot from there.' (Int A43, state vet focus group)

DARD greatly intensified its regime of random on-farm inspections of vets at TB tests following the official rebukes cited earlier. Teams of state vets therefore began inspecting their peers in the private sector in a more formalised and structured manner, aiming to keep 'relational distance' (Enticott, 2014) by inspecting away from their 'home' areas.

Enticott (2012a) analysed how vets performed TB testing on farms in GB, and suggested that attempting to enforce government testing protocols was unrealistic considering the fluidity of the conditions in which the test is performed with weather, safety considerations and time pressures to contend with. State vets certainly accepted the 'messiness' of contending with moving animals and varying conditions on the farm, but one state vet's assessment of the effect of more training and the new inspection regime was an improvement in standards:

'The level of supervisions is increasing year on year …This year for example we will do 100 supervisions out of some 300 individual PVPs, so a very large section of audit is carried out every year - up to a third of all testers in any one year, which is vastly more than any other part of the world … I am very pleased to say that what we have actually seen in parallel to this exponential rise in the number of supervisions being carried out, we are actually seeing the number of non-compliances reducing, so it's now the tip rather than a larger part of the iceberg. So yes, we are winning in terms of perceptions and in terms of attitudes towards

> the quality of testing, and we have a very good system up and running … Our efforts have been focused on improving the quality of testing, and we have made great progress on that.' (Int A55, state vet)

When asked about their standards of testing, private vets were defensive and eager to favourably compare their testing professionalism with vets in other countries. As highlighted in Chapter 6, one thought that the testing in NI was better, or at least no different, than testing elsewhere in the EU (Int A46). Another thought it better than the 'rudimentary' testing in England:

> 'We had these visitations from Europe telling us that we were doing a crap job here. I certainly get the impression that we were doing a great deal better here than in many parts of England, where testing certainly seemed to be a rudimentary kind of inspection [*laughs*].' (Int A49, private vet)

The vast majority of those interviewed vigorously disputed the assertions that their testing was not up-to-standard, and emphasized that they did their best:

> 'As a vet, I have been inspected for TB testing twice since I was approved. I passed both random inspections. I have no fear of the inspectors. When I arrive at a test, the test is done to the best of my ability. An inspector can arrive at any stage of my tests, and they can see that the job is done to perfection as far as I can do it.' (Int A17, private vet)

Several private vets were angered by the accusation that their standard of testing was not satisfactory, and in addition to vigorously defending their test performance, also countered with their own criticisms of the state:

> 'The Department had a bee in their bonnet, and have had for years, that the problem was the vets - the vets in private practice are all taking shortcuts and they're not testing properly. And the vets have got the blame. We have had all sorts of measures we have had to work with. We now get inspected and audited once a year, and it's a very draconian system, which has had a lot of negative press, and it has certainly not helped to endear a positive attitude to our system with the vets in general. We know it is public money, and there has to be public accountability, but the truth is that if the Department of Agriculture had spent as much time in being a bit more creative in looking at other areas such as reservoirs of infection in wildlife, I think it would have served our TB eradication programme probably a lot better in the long-term.' (Int A40, private vet)

Overall, there was a resigned acceptance that this was the new world of peer-on-peer veterinary governance, but one vet could not resist mentioning the irony of the disease incidence rising despite the increased supervision:

> 'I guess there has to be some sort of quality control - there's a lot of money getting spent on this - there has to be some sort of quality control. I guess we're not against it on principle, as long as it is done in a reasonable spirit and not in an aggressive and unfriendly manner.' (Int A39, private vet)

> 'But then fairly draconian measures were brought in to try and improve the level of testing here. OK, we have had to put up with that, but then we found two or three years ago that the incidence of TB suddenly started to rise, even though we were being supervised a great deal more!' (Int A49, private vet)

When farmers were asked about their views on the quality of TB testing on their farms, most gave positive responses, denying that there were poor standards. The following quotes demonstrated how farmers could be highly complimentary about the vets' professionalism in testing:

> 'It has been stated ... that they [DARD] didn't trust the vets - in other words, the vet and the farmer could be in cahoots. I would have to say that for any of the vets I have been in contact with they are far too professional for that - no, that would never happen, never happen, and nor would I want it to happen, by the way.' (Int A36, dairy farmer)

> 'Oh, my vets do their job 100%. They are very, very thorough. I always scold them and say "Boys, don't you give it to me!" and they always say "Oh, I have to do my job right" [*laughs*].' (Int A5, dairy farmer)

Although their empathy lay with the private vets and against DARD when the subject of supervision came up, this was not a universal carte blanche approval for vets to test how they pleased, as described in Chapter 6, and as this focus group interview excerpt also implied:

> 3: 'But by the same token Joe [*pseudonym*], two Department vets are standing over the practising vet inspecting him, making sure that everything is tickety-boo, who don't have the wherewithal and or the inclination to go and do the re-tests themselves, and who are fobbing that onto the practising vets, you know.'

> PR: 'That supervision thing came from the [NI Audit Office] Report in 2009 which criticised private vets and their standards of testing //'

> 2: 'But that supervision thing - I've seen it - he comes and he watches the vet do 30 animals and then he buggers off again - I mean, that's not going to ... if someone is standing there ... if you're driving into the village and you see a police speed van you slow down to 30 miles an hour [*laughs*] and once you're round the corner ... it's human nature.' (Int A58, farmer focus group)

While there was therefore scepticism about the efficacy of inspections in changing behaviour, an example was also given of the failings of SICCT test metrologies even under supervision. A farmer and his father recounted, with awareness of the irony, the story of their beef animal which had been tested as negative under DARD supervision, only to turn up at the slaughterhouse the following week with TB lesions:

> 1: 'They had a diagram that day they vetted him testing - you'll have seen it - a sheet drawing x's and o's on the sheet where the clip marks were on the neck, where the clip marks should be, and the size of the clip mark or something ... And that was, as you say, one of the ones they audited him on.'
>
> PR: 'Yes, and it was found to have TB?'
>
> 2: 'The only thing they found wrong with him [the vet] was something about [not] washing his feet.' (Int A7, beef farmers)

If, as Enticott (2012a; 2014) suggests for private vets in England and Wales, and supported by the lower odds ratios for finding reactors on farms in both NI and GB, private vets are sometimes unduly influenced by the close relationships they have with their farm clients, then systematic random inspection is one way to encourage (or force) conformity with proscribed procedure. As with the penalties imposed on farmers to ensure compliance with the subsidy regime, the threat of suspension from testing appeared to be working as a governance strategy. But the state cannot be on every farm on every day, and there is still room for resistance and tactics to avoid the grid of discipline. Whoever may or may not be to blame, it appears that supervision and further state control are to remain a feature of the TB programme, and vets do not relish the prospect. In fact, they respond with fear when the panoptic discipline of the state randomly comes their way:

Vet 2: 'All three of us have been inspected in the last 12 months.'

PR: 'How do you feel when the inspectors turn up?'

Vet 1: 'Not good, not good.'

Vet 2: 'Jane [*pseudonym*] - you answer that one.'

Vet 1: 'It's actually a terrifying experience //'

Vet 3: 'It's not pleasant.'

Vet 1: 'I guess in theory it shouldn't be, but with the best will in the world'

PR: 'Is it stressful?'

Vet 1: 'It's very, very stressful.'

Vet 3: 'Yes, yes.' (Int A39, private vets)

Although the state would not frame veterinary supervisions in this way, the effect is as Foucault (1977: 201) once suggested: the Panopticon induces 'a state of conscious and permanent visibility that assures the automatic functioning of power ... to arrange things that the surveillance is permanent in its effects, even if it is discontinuous in its action'. While farmers live in fear of state inspections for subsidies, vets may live in fear of the state's veterinary inspections, and seek to resist, citing a social injustice and unfair accusations of blame.

The threat of lay testing for TB by trained technical staff at less financial cost was seen by some interviewees as another 'stick' the state may wield to force compliance. The vet's influence as a 'professional' and 'expert' with Aesculapian authority may be powerful (Armstrong, 2011), but increasingly viewed as being under threat from neoliberal state reforms in the UK (Enticott *et al.*, 2011). Perhaps the ability to perform the TB test, enshrined in the Veterinary Surgeons' Act of 1966 as a task for vets has been viewed as empowerment for the veterinary profession. However, this privileged status has been threatened by legislation first enacted in England and Wales in 2005 to allow non-vets to continue to TB test in GB. Having been trialled in NI through a DARD pilot project but rejected for the present time, lay testers may further threaten vets' expertise as those who 'know' TB.

Improving TB detection rates and fewer non-compliances may help stave off the possibility of further neoliberal reform of TB testing, and prove that testing is performed diligently and without bias, even without sight of the veterinary 'police speed van'. The private vets in general accepted the need for inspections to safeguard the proper use of taxpayers' money, but the negotiations and experiences both on-farm during inspections, and through behind-the-scenes veterinary politics, had left some with feelings of frustration, anger, cynicism and even fear. The fractured relationships between the state and veterinary profession may take more time to repair, but show signs of beginning to heal.

Governing badgers

If state officials thought that farmers and vets had a bias towards crossing the boundaries designed to enclose and regulate their behaviour, farmers and vets in turn viewed badgers as the unruly transgressors. Exercising power over farm-space, fences are no defence against this black and white invader. Badgers live in rhizomatic underground networks called setts, only appearing above ground during the night hours to find food, making them particularly elusive and hard to govern:

> 'We've picked a dreadful disease to try and eradicate [*laughs*]. You couldn't make it up! And even [with] a wildlife host, what do you do? You pick one that comes out at night and lives down a hole! [*laughs*]' (Int A56, state vet)

Badgers have been killed (or 'culled') by the state in England since the discovery of a TB-infected badger on a cattle farm in the early 1970s to reduce the spread of disease to cattle (Dunnet *et al.*, 1986). This has certainly proved to be a contentious strategy with different conclusions drawn from the same scientific evidence base (Grant, 2009; Spencer, 2011). The present UK Coalition government instituted a further badger cull in 2013, despite controversy amongst the scientific community and the public about its efficacy and ethics (see Atkins & Robinson, 2013a). Badger culling is ongoing in the ROI, and between 5,000 and 6,000 badgers are culled each year with the aim of preparing for a mass vaccination programme when technically feasible to do so (Gormley & Corner, 2013). Despite the ongoing use of badger culling in present-day TB control strategies, questions remain. To adapt Uli Beisel's thoughts on mosquitoes in the control of malaria, the debate centres on 'whether rendering [badgers] killable is a fruitful strategy in the long-term' (Beisel, 2010: 48).

Badger vaccination against TB is suggested as an alternative strategy for reducing transmission to cattle, and it is regarded to be ethically more acceptable and sustainable in the long-term (reviewed by Robinson *et al.*, 2012b). A BCG vaccine was licensed in the UK in 2010, and this injectable vaccine is already being deployed in some regions of the UK, but there is certainly a geography of difference in terms of approach. Badger vaccination is being used in Wales over an area of approximately 300 km^2, and began in 2012 (Welsh Government, 2014). In England, vaccine trials to experiment with deployment methodologies for injectable vaccine and to seek to develop a suitable oral vaccine are ongoing. Various individuals and wildlife organizations are using the licensed vaccine on their own farms or in localized areas. No vaccination occurs in Scotland because Scotland is officially TB-free, and a strategy for capturing, testing and vaccinating TB-negative and removing TB-positive badgers is being developed in NI for expected implementation in 2014 (NI Assembly, 2013b). A UK Parliamentary Inquiry by the Environment, Food and Rural Affairs Committee reviewed the evidence for badger vaccination against TB and concluded that it was expensive and not the 'magic bullet' to solve the problem, but recommended further work should be done to consider how vaccines could be deployed effectively (House of

Commons, 2013: 25). It appears that 'immune systems have become a subject for debate' (Sloterdijk, 2009:110).

Governance by killing

Significantly, badger culling has never been approved by the state in NI, and even illegal culling of badgers by individuals appears to be at a low level (Reid *et al.*, 2012). However, the majority of farmers and vets interviewed preferred the idea of implementing state-sanctioned badger culling to vaccination. These findings were similar to the conclusion of Donaldson and Wood (2004: 385) on the control of FMD that 'such is the power of the materiality supporting slaughter that vaccination has had a subordinate role'.

The commonest argument in favour of killing badgers was that TB would never be eradicated unless 'something' was done with the 'root of the problem,' sometimes expressed in militaristic language:

> 'I think if the Department are serious about controlling TB, they have to do something with the wildlife. As far as I can hear every country who have eradicated TB or controlled TB have had to take some steps with the wildlife.' (Int A10, private vet)
>
> 'Well ... if the badgers have got TB they are going to have to try and take the badgers out ... It's test every year and if something goes down, do two tests and ... nothing has changed in the past 40 years [*sounds exasperated*]. If badgers have got it and they are giving it to the cows, well, they're going to have to get to the root of the problem.' (Int A15, dairy farmer)
>
> 'My own suspicion is that the main infection is cattle-to-cattle, and badgers are a casualty of war between TB and cattle, but badgers are certainly involved heavily in keeping infection in a premises where we are trying to eradicate it through testing and removal of animals. You can't remove one source and not remove the other and hope to win the war.' (Int A41, state vet)

A few argued that only politics and fearful politicians stopped culling taking place, and that the science was undisputed. There was also a strongly-expressed sentiment that the issue of culling was a battle of rights: the rights of wildlife supporters versus the rights of farmers; and the rights of badgers versus the rights of cattle. Much to their frustration and angst, badger rights appeared to be in the ascendancy:

> ‘The badger has more rights than the farmer or the cow. The poor cow is being slaughtered year after year while the badger runs free - what about the cow's rights? There are plenty of good cows out there who have been slaughtered for no reason, positive for TB or not ... If the farmers kicked up as much stink as these animal rights people ... But it's not in a farmer's nature to do that - they want to try and make a living and get on as normal. I am not anti-badger - don't get me wrong - the badger serves its purpose in the wildlife food chain - but it's got beyond a joke.’ (Int A17, private vet)

> ‘I always find it very intriguing that whenever you mention culling badgers all the greens and all the animal rights people all come out of the woodwork, and yet there are thousands of cows culled every year, and they never say a word about it.’ (Int A16, dairy farmer)

Several supported badger culling because they viewed badgers as dirty, worthless and overpopulated pests. Alternatively, some held a wildlife-friendly stance and argued that TB was bad for badgers, leading to slow, lingering badger deaths: ‘It's not a very nice thing from a welfare point of view for the poor badger - they are riddled with it’ (Int A40, private vet). Three farmers who were unsure about the merits of badger culling thought that they would be more likely to support it if ever their own herds became infected with TB.

Very few argued for the indiscriminate and systematic killing of badgers, and of those who did, one compared badgers to the rabbits which had been a farm pest controlled by farmers themselves taking affirmative action:

> PR: ‘Could they kill all the badgers?’
>
> ‘Why not?’
>
> PR: ‘So you wouldn't mind?’
>
> ‘No, I wouldn't mind. In the mid-60s our farm was covered in rabbits - you would have seen strips up the side of the field grazed. But now there's not a rabbit in the country - they were done away with - what's the

> difference? Badgers could be done in the same way.' (Int A12, dairy farmer)

The protective legislative framework for badgers undoubtedly restrained farmers from taking action against badgers themselves, but this was a frustration, and some argued that the protection should be removed to allow farmers to act of their own volition, as was the case for other farm threats such as foxes and crows. Of those who supported culling, the overwhelming support was for targeted culling of infected badgers in 'hotspot' areas for TB in cattle:

> 'We're not talking about every badger in NI - we're talking about diseased badgers. I mean there's cow welfare, and it's not actually good for the badgers to die of TB either ... We are not talking about the genocide of all badgers - we are talking about a targeted cull of diseased stock. We are culling diseased farm animals, and what we are talking about here is a targeted cull of diseased wildlife.' (Int A58, dairy farmer)

Another common call was for a badger culling *trial* to take place to settle the arguments about whether badgers were involved as transmitters of TB, and whether killing them helped to reduce TB in cattle. Two private vets thought that a culling trail was unlikely to resolve the argument, as was the case with the £50M state-funded Randomised Badger Culling Trial (RBCT) in England, and that the various lobbies would take from the results what they pleased (Ints A51, A52). One vet, whilst in support of culling, suggested that its success would be limited, although beneficial:

> 'I think if every badger in Ireland was removed tomorrow I still think we would have a TB issue to deal with, but I think it would be easier to deal with it. The priorities have to be development of a vaccine for badgers and cattle.' (Int A39, private vet)

Those who argued against badger culling were in the minority. Various reasons were provided: it was too difficult to conduct culling effectively; culling badgers was ethically wrong; the methodology lacked scientific proof of efficacy; culling would cause perturbation and spread the disease; and the general public would offer too much opposition and harm the reputation of the farming industry in NI. Four farmers and one vet argued that badger vaccination was a better option, but when vaccination was specifically discussed the opinions were more complex than these numbers suggests.

Governance by vaccination

Badger vaccination with BCG does not prevent infection, but reduces the severity of disease and transmissibility of infection (Robinson *et al.*, 2012b). Vaccination can therefore be described as a 're-direction of biosecurity efforts such that a fixation with barriers [is] replaced by a concern with intensities' (Hinchliffe *et al.*, 2013: 540). Like Pasteur's grand experiment on anthrax vaccination in France in 1882 (Latour, 1988), a sceptical audience waits for the proof of efficacy outside of the laboratory. This 'movement from the laboratory to the field' (Latour, 1988: 76) is therefore a crucial development in proving to farmers and vets that vaccination protects not just badgers, but more crucially reduces the threat to the cattle in their midst. There was both optimism and scepticism:

> 'I am not close enough to it to be able to say, but if someone was able to tell me that it is a good vaccine and it works - I think that is an easier route to take. If we started a vaccination programme it would at least help to reduce this problem in the wildlife sector.' (Int A50, dairy farmer)

> 'Ideally what I would love to see is no badger killed, and basically mass vaccination of all badgers ... Now I don't know much about the vaccine - I don't know whether it passes vertically to the cubs or not, but it's like any population for any disease - if you keep on vaccinating the ones that have got it will disappear eventually, and then there will be total immunity through that. And considering how many years we have been fighting this TB, a few extra added years wouldn't really matter [*laughs*].' (Int A47, state vet)

> 'It's all to be proved, or all to be tried. There are no answers.' (Int A7, beef farmer)

Despite the widespread acceptance and use of livestock vaccination, knowledge about badger TB vaccination was generally low, especially amongst farmers, with a typical response being: '[I have] a very minimal amount of knowledge about that. I have seen some of it on TV on the likes of *Country File* [BBC programme]'

(Int A18, dairy farmer). There was a common belief that it would be impossible to catch and vaccinate all badgers in a locality because of their inherent elusiveness and feral nature. The difficulties of trapping badgers were contrasted to the ease of vaccinating cattle, with a perceived gulf between scientific theory and application in the field, and a questioning of expertise:

> 'Some of these so-called experts say that the badgers should be vaccinated, but I don't think that's practical ... because you are never going to know when you have them all done.' (Int A9, dairy farmer)

> 'You never know ... sure there's a whole pile of them down the hole? You never know how many you're getting.' (Int A6, dairy farmer)

> 'The principle appeals to me, but first of all how do you catch badgers to vaccinate them? Secondly, what is the cost of the vaccination? Thirdly, does vaccination guarantee that they don't become spreaders even if they are carrying the disease? ... I know little enough about it that I would have to be asking a lot of those hard questions ... In principle I like the idea.' (Int A18, dairy farmer)

Another common belief was that it was necessary to vaccinate all badgers to have an effect: 'How can you go out there and try and trap one of them, never mind all of them, to vaccinate them?' (Int A3, dairy farmer). One farmer recognised the need to vaccinate a threshold percentage of the population rather than all of them (the epidemiological concept of 'herd immunity'), comparing it to a measles outbreak which was featured in the media at the time, but still believed that the required threshold would not be reached:

> 'You don't have to do every one, but you have to be pretty high, and I have severe doubts about how the heck you'd get your hands on all these badgers. I think you are never going to get enough of a percentage to make a go of it.' (Int A58, dairy farmer)

Some farmers were concerned about whether the vaccine would be effective, especially if badgers were already infected: 'If a badger is rotten with TB and it's spreading it round, what good is vaccinating it?' (Int A24, dairy farmer). Despite skepticism, and in the midst of the concern about the seriousness of the problem, there was still room for dry humour:

> PR: 'If there was a vaccine, who should pay for it?'
>
> 'The badgers [*all laugh*].' (Int A6, dairy farmers)

Vets were generally more positive about badger vaccination, and some saw it as a pragmatic alternative to culling. One was willing to accept vaccination even though not fully convinced of its merits:

> 'It's going to be very impractical to do it, and expensive to do it, and I think the vaccine itself is expensive. I guess it is an idea, because realistically badger culling is going nowhere, and although we might want that, it's going to be a long time before they ever cull a badger in NI in particular - so what's the alternative? Vaccinate badgers? I guess if that could be done and is effective then I have nothing against it.' (Int A39, private vet)

The findings from this research in NI broadly concur with research elsewhere in the UK. Enticott *et al.* (2012b) also found that farmers in GB were cautious about, and lacked knowledge of, badger vaccination. Sixty-one per cent of those surveyed doubted its practicality, and the same percentage favoured culling over vaccination (Enticott *et al.*, 2012b). Just over half (56%) of those I interviewed and who discussed badger vaccination were generally in favour of a role for it, and 25% were completely against it. One interviewee saw badger vaccination as a deception and 'a PR thing' designed by the state to deflect attention away from culling (Int A53, beef farmer). Badger vaccination therefore remains a 'collective experiment' where 'the laboratory has extended its walls' (Latour, 2004: 2-3) to encompass the farmland on which badgers are to be trapped and vaccinated. Farmers remain to be convinced on the efficacy and the practicalities of badger vaccination, and are aware of the hugely expensive task that vaccination with injectable vaccine remains, but one took a typically pragmatic view of the halfway position of culling infected badgers and vaccinating clean ones – DARD's proposed test, vaccinate or remove (TVR) badger management strategy:

> 'I think that is some way towards resolving the problem … as I said before we have a huge problem and if we could even half that problem, it would be a good start. If we had half the problem I would be closed [with TB

> herd restrictions] for half the time I am currently closed – that would be a real step forward for me.' (Int A50, dairy farmer)

Vaccination of the badger may provide a way of governing the badger, and offers a longer term solution which is more ethically acceptable to the public, and avoids the controversy of culling. It is though a very expensive option, with almost £927,000 being spent in 2013 to vaccinate 1,352 badgers in north Pembrokeshire (Welsh Government, 2014): a cost of £686 per badger.

Rather than defending borders, vaccination allows 'borderlands' (Hinchliffe *et al.*, 2013) of badger territory where the vaccinate itself dwells in an in-between state – possibly protected, possibly infected, but with less severe disease, and reduced capacity to transmit *M. bovis* – a confused 'topography of disease' (Hinchliffe *et al.*, 2013: 531), but one which may allow badger and bovine to co-exist in shared space, rather than creating 'pure' spaces free of badgers altogether. Creating such a badger immunopolitics instead of badger 'thanatopolitics' (Campbell, 2011b), it may be difficult to persuade farmers that vaccination is preferable to culling, but the TVR strategy appears to have some traction. What is certain is that the taming and neutralisation of TB is never an easy task, and it is going to be particularly difficult to create a 'society of hygiene' (Sloterdijk, 2004: 194) in subterranean and elusive badger populations.

Governing bovines and bacteria

With the intense focus on how to govern the badger, the bacterium itself has become the forgotten 'other'. *M. bovis*, as discussed in Chapter 7, has recalcitrant and indeterminate tendencies. Whilst so much attention has been on what to do about the badger in the TB debate, this forgotten 'other' has gone about its business of invisibly transgressing into both cow- and badger-space. More than a century ago American veterinary pathologist and bacteriologist V.A. Moore stated that: 'The only way an infectious disease can spread is by means of the germ that causes it escaping from the infected and gaining entrance to the body of the uninfected individual' (Moore, 1913: 33). According to Moore, there was a profoundly simple and eminently logical solution to TB in cattle: 'The disease is produced by the tubercle bacilli and if we keep these bacteria away from our cattle they cannot possibly develop tuberculosis' (Moore, 1905: 15). Following on from the description of conacre land and grazing patterns in the previous chapter, this section particularly elucidates opinions on protecting cattle from TB infectivity. Most interesting were the views on how cattle could be protected from TB bacteria through the practice of biosecurity outdoors at pasture.

As revealed earlier in the thesis, the complex relationship between economic reality and cultural identity is bound up in the relationship between farmers and their cattle, and this even extends to the aesthetic appearance of cattle within the landscape. For some, grazing cows on green pastures constituted a picture of idyll which engendered pride, as illustrated in the following interchange:

> PR: 'If it was a nice sunny summer's day ... and you're standing looking out at your cows grazing, how does that make you feel?'
>
> 'Oh, I'm just proud of them.'
>
> PR: 'Really?'
>
> 'Oh aye. The last night our cows were out was a Sunday night, and they were grazing up there in those fields [*points out of the window*], and it was one of those evenings where there was a bit of late evening sun - the sun was just glowing straight up into them there. And after I had my tea that evening at eight o'clock I went out there and just stood out there, and looked at them for a while. And I came in and the wife said to me: "What are you doing?" I said: "I'm just having a real good look at my cows grazing up there this evening because it's probably the last night I'll see them doing that this year - a nice evening, a real nice evening like that". And so it was.' (Int A09, dairy farmer)

Although this was typical of other farmers who felt emotionally attached to the visual landscapes created by seeing cows grazing under blue skies, pragmatism and seemingly never-ending rain had over-ruled desires for beauty in the rural landscape for some, persuading them to change the grazing patterns of generations of farmers in NI. Several dairy farmers explained how they had switched to zero-grazing regimes where their cows were housed day and night to suit their systems of management for feeding and milking. In a bid to protect the sodden land from further destruction, milking robots had been installed to suit zero-grazing policies. Bringing the field to the cow was becoming more practical and financially rewarding than taking the cow to the field. As Batterbury (2001: 453) observes, 'land cover is linked to the micropolitics of decision-making, but also to biophysical realities'. According to the farmers involved, the cows appeared more than happy with the new regime; chewing the cud whilst lying on soft foam mattresses with all the food they could eat was the new bovine bliss. What influence this increasingly common change of animal husbandry may have on TB incidence remains to be seen, but most cattle are still outdoors at pasture throughout the summer grazing season, which brings particular challenges when seeking to eradicate disease.

The land's central feature is the *mosaic*, 'where objects are aggregated, forming distinct boundaries' (Forman, 1995:4), producing heterogeneous landscapes affected by both human activities and biological processes. As visualized in the GIS images of Chapter 7, this mosaic provides a diffuse and challenging landscape in which to control the circulating materialities and disease within boundaries: 'There are some 800,000 fields in NI, with 55 million metres of fencing, 120 million metres of hedgerow, and 8 million metres of stone walls' (NI Assembly, 2012a: 80). The task of governing TB ecologies in the open is most certainly a challenging and daunting prospect as this farmer recognised:

> 'TB has been a continual, on-going disease problem for us and our neighbours, and the whole of NI since I started farming, and the situation, if anything, has deteriorated. I can still remember our first outbreak on this farm - now we are closed as often as we are open. That's another reason for keeping cows in. In the summer time we have cattle distributed over 500 acres - that's 500 acres with neighbours to possibly infect us, and its 500 acres for badgers to infect us.' (Int A50, dairy farmer)

Despite the physical boundaries between fields, Donaldson and Wood (2004: 385) illustrated how the FMD virus did not recognise 'the delineation between one farm and another'. *A priori*, the TB bacterium, another infectious agent, does not make such differentiation either, but the farmers revealed that transmission across boundaries was by no means certain. Unexpectedly, some farms survived as TB-free islands surrounded by seas of infection, and this freedom may be related to various farming tactics designed to prevent the spread of infectious bacteria across farm boundaries.

Farmers in such fortunate positions ascribed both human and material agency to maintaining disease-free statuses against the odds. Sheep were sometimes used as a buffer species to keep cattle apart, while others used electric fences to create a gap at the boundary with infected herds. One farmer grazed only the internal fields on his farm, and he had remained TB-free for over 20 years despite neighbouring herds suffering breakdowns with monotonous regularity and with badgers roaming freely over his land. A dairy farmer was grateful for the natural and man-made boundaries which the surrounding landscape provided to protect his farm – rivers, roads, and railways were mentioned as obstacles to the movement of TB between farms. Another common tactic was to grow grass for silage in boundary fields, which had an added benefit in dairy herds of keeping fields for rotational grazing nearer the farm yard for ease of access by the cows. Very few farmers mentioned co-operating with neighbours to keep their cattle apart, and for the one farmer who did, this was more to stop bulls from straying across fences into neighbouring groups of heifers rather than with the intention of protecting disease freedom. Double-fencing the boundary was rarely mentioned as a preventive measure, and was deemed useful but too expensive by those who did consider it. One farmer had double-fenced to protect his herd from a beef finisher who regularly purchased cattle and was regarded as a high-risk reservoir of disease. Double-fencing was even less likely on conacre ground, and ruled out because the farmer did not own the fields where his cattle were grazing. Smaller herds were deemed less likely to have secure perimeters to their land, with often a failure to even provide secure single perimeter fences:

> 'Some of those bigger herds are more likely to keep their ring fence better. They would have as much of their ground in one block as possible. Those guys [with small herds] would have a field taken here and there, and they're not going to be worried about the fence - if they can keep the cattle in that's all they're worried about, never mind keeping other cattle away from them. They would have cattle breaking out as well.' (Int A59, private vet)

> 'You say to a farmer "Have you got good fencing?" and he says "Yes, terrific". And you go out and look at his fencing and to a farmer it's a good fence if his cows are in the field he put them in - terrific, it works! [*laughs*] ... To him it's a perfectly good fence. Biosecurity point of view: virtually a waste of time! But to him, he's paid for it, and it's pretty good, it does his job! [*laughs*]. If you want something else ... well then he says "What - you want me to put another fence in here, 5 metres back maybe and ... How much is that going to cost me?" (Int A56, state vet)

State vets therefore thought that farmers would be reluctant to 'waste' the land between the fences to create a protective buffer zone, or to avoid grazing boundary fields given the drive to increase productivity which trumped biosecurity considerations:

> 'You are not going to change the old guys - they're not going to look at biosecurity ... Younger progressive [farmers] - yes, they would understand biosecurity, but because they are so progressive and because they are trying to pump so much out of a small area, they have to do the balancing act - and the balancing act does not take the cattle away from the [contiguous] boundaries [*laughs*]' (Int A47, state vet).

The economic landscape therefore has an impact on grazing patterns and the likelihood of farmers using strategies to avoid TB spread at pasture. While some believe in their success with good biosecurity, others are confused by the multiplicity of TB. The bacterium has power through its seeming mutability. There are different geographies (Fisher *et al.*, 2012) and even different histories (Atkins & Robinson, 2013b) of the disease. Different herds, different age groups within a herd, different strains, different geographies, different histories of infection – different, but the same; confusing heterogeneities, 'different versions of disease' (Enticott *et al.*, 2012a; Atkins & Robinson, 2013a). This is what makes *M. bovis* even more difficult to govern, and biosecurity much more challenging to order and implement. To cite Braun (2011: 400), the nature of emerging infections is 'radically open to the world, thrown into the flux of an inherently mutable molecular life where reassortment is not what we control, but what we fear'. But, as described in Chapter 5, fear of TB is often lacking amongst farmers, and the words of W.D. Hoard, speaking of the TB situation in Wisconsin more than a century ago, still ring true today: 'In the minds of farmers … there is a strong undercurrent of conviction that all this talk about the disease is an interested plea of the veterinarians … Just as long as this bank of fog exists, it will control all legislation and individual effort to get rid of the difficulty. At the bottom of the matter is a widespread ignorance on the part of farmers as to the danger that threatens them' (Moore, 1913: 119).

To address farmer unbelief, Hoard extolled the benefits of opening a diseased bovine carcase before a farming audience, and declared this a powerful demonstration of the 'ravages of the disease' (Moore, 1913: 120). Such public exhibitions, he believed, were the key to farmer acquiescence with herd testing and compliance with legislated pre-movement testing, and ultimately the prospects for success in the state TB eradication programme. A repeat performance is impossible in the present day, indeed it would be difficult to even find such an animal in the advanced stages of disease, but the fact remains that farmers do not see pathology lesions, and do not see bacteria. Belief in the need for biosecurity is often suspended for lack of evidence; a suspicion that it really is a step too far, and another bureaucratic burden hindering farming practices in the 'real' world:

> PR: ‘Do you think there's a lot of biosecurity practised on cattle farms here?’
>
> [*Laughs*] ‘Not really. I think it's only practised whenever the Farm Quality Assurance man is coming, to be honest.’ (Int A44, dairy farmer)
>
> ‘I don't think they fully understand the infectious nature of the disease, first of all, so they probably think that a lot of these [biosecurity] measures are a step too far … they feel that all this biosecurity stuff is nearly a punishment rather than a thing that is actually helping them in the long run.’ (Int A60, private vet)
>
> ‘We think biosecurity is a major part of it, but the practicality - you can't always keep a closed herd, which is DARD's suggestion. It's just not physically possible … We would encourage them to be biosecure, not necessarily to do the biosecurity training … Farmers are busy men, and if they think that they are biosecure as it is, then we shouldn't be forcing them to go down that route.’ (Int A54, UFU)

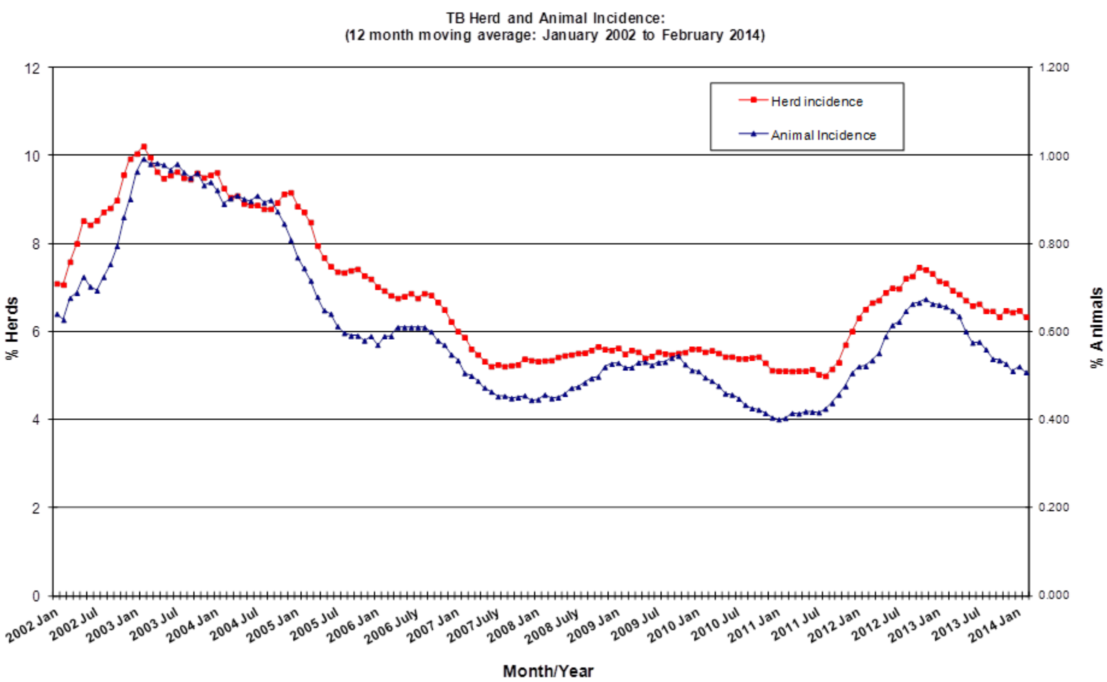
Farmers rarely considered the scale of the microscopic. To expect governance to be rescaled to the level of the microscopic is perhaps most feasible through cattle vaccination against TB, but that is neither allowable under EU legislation, nor at the present time technically achievable given the stage of research development. Farmers may not ‘see’ and appreciate the mobilities of microbes between bovine bodies, but what they *do* know and govern are the movements, and the separations, of bovine bodies. Keeping ‘closed’ herds (not purchasing cattle) and ensuring that they pay attention to where their neighbours’ cattle are grazing, may at least enable bacteria and bovines to remain apart. Avoidance of badger setts is more problematic, but again, there are measures which farmers could take to try to protect their cattle, particularly to avoid grazing fields which seem to have been infected places in the past. Then state and veterinary efforts to spread a biosecurity discourse to change the minds and wills of the farming populace may not have been in vain.

Governing the state

Having considered the governance of farmers, vets, badgers, bovines and bacteria, this chapter concludes its analysis of the geometries of governance with an examination of the governance of the state. Rather than power being unidirectional, from top down, the TB assemblage demonstrates that power flows in multiple directions and at various scales and intensities. Indeed, the 'network state' is 'highly porous to … the influences of … natural objects' (Robbins, 2008: 209) in addition to humans and their institutions.

The state seeks to govern TB through testing cattle. Unless it has numerical data on the presence or absence of the disease, there is nothing to govern towards eradication. Testing for TB is therefore an act of disclosure through which the disease becomes calculable and known (Enticott, 2001). As described in Chapter 6, skin measurements are translated to classify cattle into positive, negative and inconclusive categories. Monthly statistics on disease incidence are produced by DARD's Veterinary Epidemiology Unit, and published online (DARD, 2014b). Graphs are produced, with data at herd and animal level producing temporal trends over months and years. An infection and a disease become lines on a graph which rise and fall over time (Fig. 11). These variations are closely monitored.

Figure 11: TB herd and animal incidence: Jan 2002 - Feb 2014 (Source: DARD)



As Scott (1998: 11) suggests, this kind of narrowing of vision and simplification 'makes the phenomenon at the centre of the field of vision more legible and hence more susceptible to careful measurement and calculation'. The test results are divided into animals, herds, divisional areas, and regions. The data make an invisible disease visible to the state. As Enticott (2001: 149-150) reminds us: 'Statistics and numbers ... have long played an important role in the creation *and monitoring* of government policies [*emphasis added*]'.

But the data are not only viewed by the state, but also by those who govern the state. The state's veterinary authorities (DARD Veterinary Service) are themselves under surveillance at varying national and international scales. On a global scale, the World Animal Health Organisation (OIE) dictates the terms for trade of animals and animal products, and also the means for certifying freedom for disease through diagnostics (OIE, 2013). The EU has a keen interest in the TB data, and an annual report is filed through the UK government with the European Commission partly in return for EU monies to help fund the programme, but also to prove that intense efforts are being made to eradicate the disease. European Federal and Veterinary Office (FVO) inspectors come to inspect the programme's fitness for purpose, and see the practical outworking of TB governance at farm level through random inspections (European Commission, 2004). Criticisms are fed back from the Commission, and remedial action is expected. On the zoonotic disease front the European Food Safety Authority (EFSA) monitors the figures for both animals and human cases of *M. bovis* infection, collating data to report annually for all Member States (EFSA/ECDC, 2014).

Closer to home, a series of high-profile audits and inquiries have reported on the TB programme performance. These reports have been highly critical of DARD and the failure to eradicate TB. The Public Accounts Committee Report on TB (PAC, 2009) stated that DARD had failed to meet the challenge of eradicating the disease and that it would have to work more closely with the cattle industry and private vets than it had done until then. The NI Audit Office Report (NIAO, 2009: 4) stated that: ‘Bovine TB has been a long-standing major problem in NI and the Department’s progress in tackling it has been slow’. Agrawal (2005: 62) shows how foresters in colonial India saw ‘statistical tables about forests as precise, apolitical representations of their estate,’ but if such motivations have affected state vets, they have failed to avoid this critical *political* scrutiny. The trend lines of TB, and particularly lines depicting *increasing* disease incidence, have been a cause for consternation for the NI Assembly’s Agriculture and Rural Development Committee:

‘The Department appears to be no nearer eradicating than it was 15 years ago … The rate fell to an all-time historic low of 4.99% in August 2011. However, it has since risen to 6.99% on 30th June 2012 … The Committee is very concerned with what it sees is such a substantial increase (40%) in rates in such a comparatively short space of time’ (NI Assembly, 2012a: 8-9).

Just as the numbers increased to mid-2012, they increased further thereafter and then decreased again without apparent explanation (Fig. 4). One state vet described such vagaries as ‘a diagnostic wave’ (Int A56), and urged consideration of a wider outlook rather than focusing on fluctuations in the trend line:

> ‘There’s a bigger picture here. We are looking at a finely sandpapered level of disease that goes up and down every few years. It doesn't get out of control - it flares up a little bit, but drops for some reason - it could be a diagnostic reason, it could be real disease - a mixture of things. But overall, clinical disease has gone; it's gone out of people, this is only a diagnostic wave that we're seeing …’ (Int A56, state vet)

TB measurements and numbers, it appears, can deflect attention from the bigger picture and portray failure rather than success – but all such knowledges are in the eye of the beholder and the perspective which he or she may take in seeking to know and govern TB *statistically*.

More recently, the NI Assembly's Agriculture and Rural Development Committee questioned whether DARD was truly committed to eradicating TB, or merely satisfied with containing the problem (NI Assembly, 2012a). One Committee member declared that 'farmers … [were] working with DARD's legacy of failure every day' (NI Assembly, 2012a: 67). There was also stern criticism, and the perception that DARD needed to be more pro-active in its governance of TB amongst my interviewees:

> 'First of all, I think that if DARD adopted an aggressive policy of TB eradication it would help us … Until DARD signal that then we are going to stumble along in the way that we have been doing for quite a long time, and that not only is affecting the farmers whose herds are closed, but it's also affecting NI plc … So we need a clear policy goal for DARD, and a road map to take us there, and that's what I think is really, really missing.' (Int A57, MEP)

> 'Considering where we are, with what has happened to the eradication programme to this point in time, I think the farming lobby think that … DARD has been incompetent.' (Int A40, private vet)

The members of the farmer focus group were also very critical of the Department's approach to TB eradication, and they blamed what they saw as a risk-averse and self-interested culture within the Civil Service for a lack of progress towards eradication:

> Farmer 2: 'There's also an issue within the Civil Service broadly that you don't take risks, you know. I'm saying "If you've always done what you've always done, you'll always get what you've always got", but the problem is that within the Civil Service there is "No, you do not take risks." You put everything through six committees and if you're in doubt do nothing, because if you take a risk and it goes wrong … protect your own [backside]. It's a cultural problem within the Civil Service, that you don't take risks.'

> Farmer 3: 'Civil Service full stop.'

> Farmer 2: 'You know the Civil Service does not reward risk-taking, but we are going to have to tackle this, and do some things which are quite drastic, quite innovative, controversial … and those are all words which make civil servants have nightmares, you know. So it's the culture within … and talking to people from other departments, DARD is seen as one of the least imaginative departments out there [*laughs*].'

> Farmer 1: 'And this is not being politically correct either - why would they bother?'
>
> Farmer 2: 'Yes.'
>
> Farmer 3: 'The salaries they are on.'
>
> Farmer 1: 'Fair play to you, but it's keeping you in work.' (Int A58, farmer focus group)

Living in an era where virtually the entire globe is 'administered space' (Scott, 2009: 324), including farm space, farmers in turn seek to mould 'state space' (Scott, 2009: 40). Appealing for DARD to change its attitude towards farmers, they sought a more 'flexible', 'reasonable', 'sympathetic' and 'common-sense' approach from those who governed them:

> PR: 'What you think needs to be changed - what would your message be in a sentence or two?'
>
> [*Sighs*] 'Oh, get their finger out and start being a bit more sympathetic towards farmers, you know? Me being a closed herd - why should I have to be under the same restrictions as [neighbouring farmer] down here who sells to anybody? And that cut no dice with that woman [state vet] whatsoever: "Oh no, it has to be done - European rules"' (Int A34, beef farmer)
>
> 'The Department can be very stringent in their rules I think. A wee bit of lee-way might be nice.' (Int A36, dairy farmer)
>
> 'Yeah, it's just like me with your woman [state vet] ... there was no discussion whatsoever - it was just point blank. You might as well have been talking to that wall - that's it.' (Int A38, beef farmer)

Adopting a virtually unique position amongst the farmers interviewed, one offered some sympathy: 'I wouldn't like to be in the position of trying to solve the problem. They would have had it solved by now if there had been a solution [*laughs*]' (Int A30, dairy farmer). Rather than seeking to govern disease at farm level themselves, the main focus of attention from farmers was on the state's role in eradication, and in this sense their main orientation was towards moulding the state to take what action they deemed necessary, particularly concerning badgers, as was earlier discussed in this chapter.

In response to the criticisms, a state vet offered the following explanation to defend the state's approach and apparent lack of 'success':

> 'The medics haven't botched control of the flu, because it's not realistic to expect to eradicate influenza in humans … nobody realistically expects there to be no more colds and flus in humans. I think TB unfortunately is a bit in that category …In the 1980s we talked eradication, and anybody who didn't talk eradication they said "Oh, you can't do that, we're going to eradicate – you're a deserter, a traitor". The more we have looked at the disease, the more we have realised a lot of it is actually outside of our control, and it's not a lack of enthusiasm or a lack of confidence, or laziness or whatever that stops us doing it. It's just that some of these things just aren't easily controllable, and so there's a gradual realisation that we are not about to eradicate in the short term.' (Int A42, state vet)

This view resonates with the geographical and STS literatures on controlling nature. As Macnaghten and Urry (1998) argue, there are difficulties in trying to govern nature when life is so uncertain and unpredictable. This is particularly evident in attempting to control the biophysical world, where animal diseases such as FMD and avian influenza often erupt unexpectedly in animal populations and resist attempts to bring them under control (Law, 2006; Clark, 2007; Law & Mol, 2008). In this sense, non-humans govern the institutions which seek to rule over them (Robbins, 2012a). *M. bovis* has quite successfully resisted more than 50 years of attempts to 'discipline' a microbe (Ingram, 2007), confirming Latour's assertion on the difficulties of such mastery:

'Natural objects are naturally *recalcitrant*; the last thing that one scientist will say about them is that they are fully masterable. On the contrary, they always resist and make a shambles of our pretentions to control' (Latour, 2000: 116).

Ignoring or underestimating the potentialities and forcefulness of vibrant matter (Bennett, 2010) is a dangerous thing to do. Objects (if a bacterium can be described as an 'object') are 'force-full' – 'smouldering furnaces of affects that are capable of creating, *policing*, and destroying the very contours of existence [*emphasis added*]' (Shaw, 2012: 613). Political ecology literatures also contains numerous examples of where the state has attempted to control 'inventive life' and has struggled or completely failed in the task (Braun, 2008; Braun, 2011). Mosquitoes, viruses, fungi, locusts and elk have all evaded and shaped state governance to varying degrees (Robbins, 2006; Perkins, 2007; Shaw *et al.*, 2010; Tedesco *et al.*, 2010; Scott *et al.*, 2012; Peloquin, 2013).

What then to conclude? Eradication has been achieved in many other developed nations, but is it achievable in NI? Pool suggested in 1945 that: 'Tuberculosis is an example of a disease, for which a far greater and more concerted effort is required than has hitherto been envisaged' (Pool, 1945: 81). 'More concerted effort' may help move towards the target, but if the eradication of TB is the goal to be greatly strived after by scientists, politicians and policy makers alike, it seems apposite to remember that 'nature is an ever-receding object that escapes the scientist's grasp … and generates anxiety through the impossibility of possession' (Robbins & Moore, 2012: 10).

Not all diseases prove easy to eradicate, even with the best of intentions. Polio, cholera, yaws, and malaria are all examples of human diseases which have proven fiendishly difficult to suppress (Greenwood, 2009; Hamlin, 2009; Closser, 2012; Rinaldi, 2012). Very few farming interviewees thought that TB would ever be governed through to eradication, and vets thought it would take a very long time. The unruliness and powerful resistance of TB continues to govern and mould farmers, vets and the state, creating anxiety and even despair. Significantly, its political actions remain largely invisible: all eyes are focused instead on the state.

Network governance

Writing about the TB eradication programme in the ROI in the mid-1980s, O'Connor (1986: 66) stated: 'We are dealing with a very difficult problem for which there is no easy solution, and when things do not come right everybody tends to blame everybody else.' Most of the blame today appears to be directed towards the state, and private vets thought that DARD was keen on partnership with them to help 'share the blame' (Int A39). One private vet who had been involved in the politics of TB as a representative for his profession thought that there was a degree of tokenism about discussions with state officials, and that the engagements (and their outcomes) in the past were not what they could or should have been, with little tangible in the way of results:

> 'To me it was the way forward, because it's like everything - if you have people sitting around the table discussing the problems and sorting out the problems, then that is the way to do it ... But ... farmers and vets tend to be practical people, so if we are going to spend time sitting down and discussing problems we want a result at the end of it, otherwise it's a waste of everybody's time.' (Int A52, private vet)

The current governance arrangements do not appear to be working very well, and alternatives need to be considered which move away from the blame and counter-blame of the past and present. Rather than looking towards the state to provide all the solutions, an alternative model is a 'network governance' approach, which political scientist Maarten Hajer (2009: 30-31) defines as follows: 'An approach to public problem-solving in which we no longer simply rely on the state to impose solutions, but instead conceive of problem-solving as a collaborative effort in which a network of actors, including both state and non-state organizations, play a part'. He further explains that this means organizing the actors around the problem, seeking constructively to find solutions agreeable to all (Hajer, 2009). This provides a middle way between the 'hierarchical control of the state and the competitive regulation of the market' (Sørensen & Torfing, 2007: 11), albeit constrained by the legislative conditions which ultimately frame any network deliberations.

The STS literatures on contentious issues suggests that some groundwork, some opening out, is required before such a process can begin in earnest: 'Every decision-making process requires a work of opening out, of diffusion, if only because of the need to mobilize the actors who will enable the project to be brought to a successful conclusion … Deciding is opening Pandora's box by permitting actors previously held at arm's length to take part in a dynamic to which they quickly contribute' (Callon *et al.*, 2011: 30).

For farmers, coming in from arm's length may mean accepting DARD's role in proving compliance with the conditions of the EU subsidy regime and not allowing subsidy governance, on which they ultimately depend, to mar relationships on disease control. It will also mean farmers taking more responsibility for disease prevention at farm and individual animal level, seeking to halt the spread of infection through enhanced attention to biosecurity.

For state veterinary services, it will mean listening more to farmers and seeking to understand their positions more sympathetically, and with due cognisance and respect for their expert knowledges of farming. Farmer engagement will no longer be a perfunctory exercise designed to comply with public consultation requirements. Such a state organisation will also be able to take criticism constructively, and seek to continually improve its performance standards at the centre and the periphery. As Tania Murray Li (2007: 280) asserts: 'A state … agency willing to govern and improve itself in dialogue with its critics, learning from scientists and the new experts in community, strengthens its claim to govern'.

For private vets, it will mean acceptance of state testing inspections and accountability in the governance of public monies. It will mean rebuilding the broken relationships at a political level, and working in partnership with their colleagues in the state sector to investigate TB and advise farmers how to reduce the risk of disease introduction. For politicians and industry representative bodies network governance will mean more realism on the size and complexity of the challenge ahead, and more appreciation of the unpredictability of knowing and governing nature.

Li warns that this process of multi-stakeholder engagement can be difficult: 'Sparks fly. Disgruntled parties walk out. There are risks involved in assembling people in one place' (Li, 2007: 282). Continual work is required to keep the elements of the assemblage hanging together. What she discusses in relation to forest management in Indonesia, on first appearances a world removed from cattle farming in NI, can be applied to improving the prospects of the control and drive towards eradication of TB in the Province, because there must be a 'will to govern and not simply to coerce' (Li, 2007: 287). Conversely, the governed may also make themselves more easily governed.

Governing more than a disease

In a culture of everyone watching everyone else, 'the watchtower occupant, as well as being a vehicle of Panoptic power, is also subject to it' (Crossley, 1993: 403). As described earlier, DARD is 'subject to frequent, irregular and unannounced inspections by an external body' (Crossley, 1993: 403), whether that be the Audit Office, the NI Assembly, or the European Commission's Food and Veterinary Office (FVO) inspectors. TB statistics collected in the watchtower come under intense scrutiny, and DARD is under the spotlight of powerful political gazes. They cannot afford to be found wanting in governance; a lot of money is at stake:

> 'In the short-term we are ensuring that our NI TB plan is approved for the UK TB eradication plan, which allows us to draw down European funding, and supports a £1B per year export trade in milk and meat and animals, but ultimately we are aiming for eradication.' (Int A55, state vet)

What this chapter has demonstrated is that the governance and power geometries of TB eradication are complicated matters and involve more than simply controlling a disease. Wrapped up within that object is the governance of farmers, vets, badgers, bovines, bacteria and even the state itself. There are mixed emotions amongst the human actors involved – anger, frustration, disillusionment, despair, confusion - but not much hope. There are lively and powerful agencies (human and non-human) at work; eradication is no straightforward matter. A key to future progress may be to rescale and reconfigure governance (Batterbury & Fernando, 2006; Allen & Cochrane, 2010). In drawing conclusions in Chapter 9, further thought is given to what the future might look like with a different, more networked governance structure across multiple scales now that all the links in the chain of explanation have been considered in this political ecology of TB.

Chapter 9: Conclusion - political ecology that 'works' and is 'useful'

This final chapter will firstly discuss the contribution the thesis makes academically, particularly to the literatures of human geography and political ecology. Secondly, it considers what the 'chain of explanation' contributes towards understanding the ongoing problem of TB in NI. Thirdly, it provides an assessment of whether this approach has produced a political ecology which 'works' (Blaikie, 2008) and is 'useful' (Blaikie, 2012). Or, to use one of Blaikie's metaphors, do the views from the *veld* (farmers and private vets) speak to the *verandah* (state veterinary officials and policy makers) (Blaikie, 2001)? Allied to this, fourthly, is an assessment of the wider role of geography in speaking to policy, given that this PhD research was funded by the state explicitly within a policy development framework. Finally, I suggest issues for policy makers to consider in developing the future direction of the TB eradication programme in NI.

The academic contribution of the thesis

Commissioned by policy makers, this is the first known study of TB in NI to use a social science approach to empirically investigate the disease and the eradication programme. NI is different to the rest of the UK and the regional differences are important when analysing the socio-economic context and epidemiology of TB. Given the relatively higher importance of cattle farming to the NI economy, the higher percentage of family farms, different governance structures, higher stocking densities and levels of cattle movement, more fragmented landholdings, and higher overall incidence levels of disease over a more prolonged period of time when compared to GB, there is great merit in focussing explicitly on TB in this region. Acknowledging the spatial and temporal heterogeneity of both the disease and efforts to control and eradicate it across the British Isles shows that policy development in NI is best guided by empirical research findings from NI.

Considered in the light of the existing geographical literatures on TB, this research particularly emphasizes the seldom-examined political economic context of the disease in cattle, demonstrating the multiple social, economic and ecological pressures on cattle farmers and cattle production, and arguing that regulatory burdens have created disenchantment and disengagement from the state in disease control. Influenced by STS, and made possible because of my positionality as both veterinary scientist *and* ethnographer, the account provides a novel ethnography of the bacterium *M. bovis*. Despite the discourses on the importance of biosecurity, both in the literature and in the field, the causal bacterium is often overlooked as a complex and recalcitrant actor in efforts to eradicate TB. This has significance for efforts to eradicate TB not just regionally in one part of the UK, but internationally. The challenge therefore of taming and governing the messy complexities of TB, of attempts indeed to create order from disorder, is a thread running throughout the thesis.

Within the sub-discipline of political ecology, first world capitalist agriculture has been a developing (yet still a minority) interest, and as mentioned in Chapter 1, this study begins to answer Galt's (2013a) call for this gap in the literature to be addressed. It is the first time TB eradication has been approached from a political ecology perspective, and the approach of combining veterinary science with human geography produces an account which is both an applied political ecology of agriculture *and* a political ecology of health, expanding the horizons to include *animal* health. In highlighting the creation of landscapes of disease through animal and bacterial mobilities between farms and across field boundaries, it brings the importance of *ecology* back into political ecology (Walker, 2005). By involving a wide range of both human and non-human actors, this merging of political ecology and STS approaches and perspectives emphasizes how nature and society are entangled and co-produced, taking political ecology in new directions whilst remaining anchored to its core themes, approaches and values, as demonstrated by the links in the chain of explanation.

The chain of explanation summarized

This case study has looked at the views of farmers, but also of vets and state officials, looking 'up' as well as 'down'. Approaching the subject from a political ecology perspective, the study has sought to answer two key questions, the first of which is as follows:

> Why has TB not been eradicated from NI despite a comprehensive state control strategy spanning more than five decades?

In Chapter 1, the 'chain of explanation' was introduced as a method for breaking the problem into constituent parts to disentangle the complexity of the whole. In this way the chain can be considered a 'device' according to Law and Ruppert's (2013: 230) use of the word: 'arrangements … [which] *do* things [emphasis in original]'. The function of this particular device was to 'assemble and arrange the world [of TB] in specific social and material patterns' (Law & Ruppert, 2013: 230). Rather than a complex whole, the chain has broken the problem into constituent parts, guided by my prior experiences and 'pre-understanding' of the TB programme and its likely 'matters of concern' (Latour, 2004). After introducing the ethnographic methodologies and reflecting on my positionality as a researcher in Chapter 2, each subsequent chapter sought to answer one subsidiary research question. What follows is a summary assessment of these empirical findings.

Chapter 3 provided *historical context* for the current TB programme. The early years of the programme demonstrated the importance of export market considerations in the push to control the disease, similar to the present day. Despite a very successful first decade of the statutory eradication programme, after which TB herd incidence had been reduced to 0.50% by 1970, a reduced frequency of testing concurrent with a rapidly increasing cattle population in the early 1970s meant that the disease took hold once again. The roots of issues and problems today have been present since then. Debates around the role of farmers, the performance of TB testing by vets, attempts to improve governance, and confusion over how to reduce the spread of TB are all present in the minutes and memoranda of the mid-1970s. With the benefit of hindsight it appears to have been premature to reduce herd testing frequency in the early 1970s. If testing had continued as annual rather than becoming biennial and then triennial, it could be postulated that we may not have the problem that exists today. Taking the foot off the TB testing pedal appears to have been a false economy with long-term consequences.

Chapter 4 also provided context, demonstrating how TB fits within the political, economic, ecological and emotional complexities of everyday *farming life* in NI in the 21st century. This chapter revealed the competitive business environment in which cattle farming operates, with global markets creating pressure on fulltime farmers to increase efficiency and maximize output. Woods (2013: 113) suggests that 'globalization is arguably the most prevalent force reshaping rural localities around the world today,' and dairy farmers in particular were very aware of their place in a global commodity market. This had forced the majority to expand their enterprises to achieve economies of scale through building larger herds with higher yielding cows. As described in Chapter 7, this has important implications for the ecologies of spread of TB, with more land being required to maintain these larger herds, often resulting in fragmented farm holdings and increased potential to acquire infection.

The spectre of regulatory scrutiny also dominates the European farming landscape, reshaping farmers and increasing their alienation from the state in its role as enforcer of EU and UK legislation. As a result, many farmers are reluctant to engage with the state, and that affects relationships and aspirations for partnership in disease control. TB is but one potential stress factor amongst many, and as such attention to TB often becomes relegated on the list of everyday priorities – other threats may be much more imminent and real. Alternatively, for some who have endured TB breakdowns for prolonged periods of time the stress is *very* real and dominates all else.

The focus in Chapter 5 was on exploring *what TB is*, and how its behaviours provide the 'biography' of a disease. It is difficult to know TB as it is complex and invites confusion. There are multiple framings of TB, illustrating the diversity of knowledge and experience of the disease on the frontline. Just as Hamlin (2009) struggled to 'know' another troublesome bacterial disease – cholera – it is difficult to pin down and define TB, and this adds to the difficulty (or perhaps *explains*) why TB has proven so difficult to govern. The conflicting framings of the disease mean that one-size-fits-all approaches to policy are unlikely to succeed with TB (Atkins & Robinson, 2013a); instead, 'policy must be necessarily plural and conditional' (Leach & Scoones, 2013: 16). For farmers adept in finding solutions and solving problems through lifelong learning and practical know-how, TB may appear beyond their power to affect change because it is invisible and amorphous. The confusion is not just on the frontline of the farm, but also extends into the scientific laboratory, where TB's hidden secrets continue to stretch scientific minds. What is clear is that TB is no longer feared as a zoonosis, and for some it has become a commonplace which anaesthetizes perception of its threat.

The state attempts to raise awareness of the risk, but as O'Neill and Nicholson-Cole (2009) discovered for changing attitudes to climate change: 'Fear won't do it'. Insulated by the guarantee of compensation for reactors, there is little fear of stigma, contagion or cost for many farmers when it comes to preventing TB in the herd. Instead, there needs to be a clearer economic case to change attitudes to TB amongst farmers, but statistics on their own will not be enough. There is a need to make TB visible again: the lack of clinical signs militates against taking the disease seriously.

Chapter 6 showed that many farmers regard *testing* for TB rather than the infection and its aftermath as 'the disease'. TB testing was universally unpopular amongst farmers. Even vets suggested that the tuberculin skin test was antiquated and outdated, not in keeping with modern technological and scientific progress. The chapter described how the test often failed to reveal truly infected animals (false negatives) and on other occasions gave false positives, adding to the scepticism of farmers about its diagnostic value. The embodied performance of the test by vets under difficult farm conditions was illustrated through a testing narrative, revealing that taking the science of metrology into the field is often a messy business. In measuring fluid skin swellings to produce numbers, the circumstances of their production (Latour & Woolgar, 1979) are concealed in the presentation of lines on a graph and statistics in state reports.

The contingencies of relations between the agencies involved in testing along with the loss of faith have combined to produce further programme failures. This is despite the efforts of the state to discipline and regulate vets in their performance of the test. The fluidity of the test will always escape efforts to control to some degree, but it is currently (and unfortunately) the best technology available to diagnose TB in the field. Uncertainties in the current system must be acknowledged and failings endured. Alternatives must be hoped for, and actively pursued through further scientific research.

Chapter 7 explained the complex *ecologies* of TB. Considering the animal mobilities, both bovine and badger, which create and affect the disease landscape, the chapter investigated how TB moves or is carried between bovines, badgers, fields and farms. Farmers are generally not avoiding the use of 'infected places' because they are trying to maximise production from every square metre of land they own or rent. Increasing herd sizes have generated a scramble for land, with farm holdings often using multiple parcels of land. Cattle herds are therefore being exposed to multiple other herds, providing opportunity for the infection to move across boundaries through direct contact between cattle over fences, or cattle straying into neighbouring fields. Cattle also move regularly from herd to herd in a culture of trading which is socio-cultural as well as economic.

Badgers (and sometimes deer, it seems) also help to mobilize the infection, meeting cattle in farm-space, both at pasture and in farm buildings, and all actors are convinced of the role of the badger in spreading disease. Nevertheless, 'clean' badgers appear to protect cattle from disease by occupying space which excludes infected others. At the centre of these ecologies of TB is a bacterium, the 'forgotten' actor seldom mentioned, and whose lively ecologies confuse, confound, and often surprise. Most worrying for state veterinary authorities is its tendency to become latent, hiding its presence until re-activating to unexpectedly cause damage even years later. It has been underestimated by some and ignored by others.

Governance was the theme of Chapter 8, and this demonstrated that TB governance is about more than a governing a disease. Rather, governance encompasses efforts to control farmers, vets, badgers, the state and a bacterium. A failure to adequately consider social justice in policy making, and the unintended consequences of EU farm policy, have incited resistance amongst farmers and a lack of buy-in to the eradication effort. They comply because legislation demands that they do so and financial subsidy penalties ensue if they refuse the grid of discipline. Farmers themselves recognise a tendency towards boundary-crossing amongst their peers, and this mild to moderate resistance is thought to greatly undermine TB eradication efforts by the state. Farmers are unwilling to promote industry governance of TB as an alternative, ironically accepting state 'policing' of the programme to prevent incoherence and disintegration despite their steadfast resistance to state 'interference'.

With questions raised over the quality of testing, and statistics to back the argument, the state has increased the policing of vets through testing supervisions. The questioning of their professional standards has not been well received by private vets and tensions have developed between the vets and their paymasters. These tensions have a long history, having been a feature of state vet-private vet relations to varying degrees since the 1970s.

The governance of badgers is almost universally believed to be part of the future for successful TB eradication, but opinions are divided on what to do about the badger. The majority of farmers and vets favour culling over vaccination, but most knew little about the detail of what badger vaccination would achieve or how it could be implemented. The views on culling were more nuanced than some might expect – few were in favour of wholesale slaughter; more were in favour of targeted and selective culling of infected badgers.

Although state discourses on implementing biosecurity are seen as being linked to progress on TB eradication, farmers appeared reluctant to invest more time and effort into trying to reduce or prevent TB mobility with perceptions of low risk of incursion. Some, by way of accident of circumstances or through deliberate farming strategies, seemed able to avoid TB despite being surrounded by seas of infection. This offers hope that there are ways farmers can avoid TB by separating bovine bodies in time and space through simple farming strategies to create buffer zones between herds.

In addition to governing all of the other players in TB eradication, the state is in turn governed by both supra-national and national institutions and legislation. Sensitive to criticism of governance failures, the state has reacted to increase its governance of vets and farmers in the hope that this will govern the disease and ensure the lines on the TB incidence graph show diminishing returns of reactor animals.

In summing up, what all of these explanations have shown is that '[TB] policy does not work itself out on a blank canvas, but is embedded in state, regional and local political ecologies' (Blaikie & Springate-Baginski, 2007: 10). Even wider than this, these ecologies operate within a framework of global political economic forces regulating world trade in animals and animal products. I have shown how the disease permeates time and space, shaped by economic forces, technologies of detection, political structures, cultural practices, and complex ecologies involving animals within the environment. These provide explanations for the historical and geographical patterns of the disease. Drawn together, these links in the chain account for why TB remains an intractable problem and a demanding challenge for TB policy makers. To adapt Robbins and Bishop (2008:754) to an animal (rather than human) health context: 'No account of [animal] health knowledge and global ... capital makes sense in the absence of an understanding of the micropolitics of production and reproduction [on farms], from which resources and labour flows, through which non-humans move and act, and against which disease, state power, and capital hammer away in the myriad realities of daily [agricultural] life'. The chain links are partial and fractal explanations, and there is always more to be discovered and explained, but they have provided a political ecology which 'works' (Blaikie, 2008) and is 'useful' (Blaikie, 2012), and the next section explores how and why.

Making political ecology work

The second primary research question which this research sought to address was:

> Approaching the problem from a political ecology perspective, can such a qualitative ethnographic investigation of the problem provide critical analysis and suggest workable policy solutions?

Social science has a constructive role to play in both the development and evaluation of animal health policy. Animal disease control, even in the developed world, often operates in an environment of mistrust and with a lack of communication between stakeholders (Catley *et al.*, 2012). For TB, there is great merit in understanding more of farmer attitudes to the disease, providing insights not apparent through representative farming bodies and political representations (Catley *et al.*, 2012). As Andrew Sayer (2011: 250) has suggested, 'social science must always begin with an attempt to understand the 'target group's' own interpretation of their condition'. Similarly, Wyn Grant (2009: 570) concludes: 'What one needs is an understanding of how the policy problem is constructed, often from different assumptions which lead to divergent conclusions'.

Ethnographic investigations with the various actors are the best way to find out how the problem is constructed, and the answer to the above research question is therefore a resounding 'Yes'. As considered in the introduction to the thesis in Chapter 1, political ecology should, can and must engage with policy questions outside of the academy. Blaikie (2012: 233) argues that for political ecology 'to be engaged and instrumentally useful … [it] has to share the knowledgescape with diverse others, most of whom have never heard of [it]'. I could almost guarantee that no vets, farmers or state officials who may have an interest in the findings of this thesis have ever heard of political ecology, but that does not deny the usefulness of this holistic approach. Even within the discipline of geography there is often a foggy knowledge and appreciation of what political ecology represents. Blaikie (2012: 233) acknowledges that, for some, it is a 'mish-mash of politics and science, of reason and representation and of logical positivism and social constructivism', but this fits with the messy and complex assemblage that is TB. The enmeshment of human and non-human, biology and technology, macroscopic and microscopic may indeed be a 'mish-mash,' but it is surely one which suits a political ecology approach influenced by STS, bridging the gap between natural and social science.

How does this help policy making? As described through the chain of explanation, TB is a messy reality, known and unknown, straightforward and confusing at one and the same time. Nevertheless, given the critical realist approach to this research, there are ways to cut through opacity to make deductions and 'synthesize ideas out of messy complexity' (Muldavin, 2008: 695). As Blaikie (2012: 234) puts it: 'A critical realist PE [political ecology] acknowledges discourse, language and the unequal power that produces it and is produced by it, as well as an appeal to an external reality and an acknowledgement of the importance of evidence and empirical research'. *Critical* political ecology is good, indeed necessary, but as Blaikie points out, approaches which destructively critique but provide no solutions or recommendations have little appeal to policy makers. Instead, they want to be 'given suggestions about "what to do" for the best' (Blaikie, 2008: 769). This means bringing together the various constructions of nature and carefully combining them with grounded truths and scientific evidence (Blaikie, 2001). The results, and the process through which they have been generated, must be convincing if they are to have impact in the corridors of state power.

There are political ecologists who are wary of engaging with policy makers, and especially of being funded by them, 'due to fears of incorporation, compromising terms of reference … and abandonment of critique and ideological purity' (Blaikie, 2008: 768). But this has not been my experience thus far. The engagement has been positive, and the approach is one which others should consider given its adaptability across the spectrum of policy debates surrounding complex environmental issues. Political ecology has proven its usefulness in this case study of TB. It can combine multiple scales in the same analysis and values empirical ethnographic research with the actors on the frontline. This values the insights and opinions of those who manage the land and the animals just as much as those who make policy decisions in the seat of government and everywhere in-between. As such, political ecology is full of 'burgeoning vitality' and it certainly 'works' (Blaikie, 2008: 771).

Policy research in geography

In addition to a political ecology that 'works' this research raises a wider question about the potential of geography to help policy makers struggling with the dynamic complexities of policy making in the 21st century. Debates about policy research in geography have been ongoing for some time with division on 'the appropriateness, extent and impact' of engagement with policy makers (Woods, 2011: 200). Policy research has been regarded by some human geographers as 'the grey 'other' of academic research' (Peck, 1999: 131), by implication dull and unpublishable, peripheral to the pursuit of a successful career in the academy. Peck (1999: 131), himself in favour of engaging with policy, described a perceived distinction within geography between 'manual' [policy] research and mental [theoretical] labour', with policy research associated with 'getting one's hands dirty'. Perhaps because of this, rural geographers have embraced policy research wholeheartedly, especially with respect to analyses of agri-environmental policy implementation on farms (Morris, 2006b). Likewise, Ron Martin (an economic geographer) states that 'policy-making of one kind or another is a prominent and pervasive feature of modern society, affecting the daily lives of us all. As geographers we should be striving to inform and shape the process and improve the outcomes' (Martin, 2001: 190). The 'impact agenda' of the Research Excellence Framework (REF) is arguably making policy work more attractive to geographers, adding to the body of work already being done.

Although many academic researchers have little or no experience of working in government (Woods & Gardner, 2011), I had the distinct advantage of having worked for the department which had commissioned the research and already possessed the 'good collaborative relationships with state actors' (McGuirk, 2011: 235). I certainly agree with Woods' (2011: 243) point that 'working with government … to help develop policies to tackle disadvantage and inequality is a progressive action, not collusion with the dark side, or "getting our hands dirty"'. As Woods and Gardner (2011: 208) found in their experiences of policy engagement, the best research topics are those where 'government has recognized a problem but knows that it does not have the full answer.' TB is a perfect example of such a problem, and is far from being dull or 'grey'.

Embracing the challenges of policy engagement, Peck (1999: 134) encouraged geographers to stick to their principles and methodologies: 'If geographers are to rise up the policy hierarchy, if they are to get the minister's ear, they will need to find convincing answers to such questions without in any way compromising … the real strengths of their distinctive approach.' This PhD has been directly commissioned by policy makers as part of the *DARD Evidence and Innovation Strategy (2009-2013)*, designed to provide an evidence base for policy making and services and to promote innovation in the agri-food industry in NI. It therefore has a distinct advantage - a copy of the thesis will land on the desk of a policy maker at the conclusion of the process. Whether its findings will be accepted and acted upon is of course a different matter, a political matter indeed, over which my influence is more limited. Policy relevance and usefulness may be only in the eye of the beholder (Neumann, 2008) but there are grounds for optimism rather than pessimism in this particular case.

Enlarging the range of vision to consider the role of geography at a wider level I would argue that there is a case for integrating social scientists into policy teams for animal disease control. As described in Chapter 2, there have been repeated calls in the literatures of veterinary epidemiology for more social science research and it seems that there is an open door for geographers to enter into animal health domains. A contingent of human geographers in the UK has already ventured into the field of veterinary science and animal disease, particularly in relation to farm biosecurity. The move is also happening in reverse with vets increasingly using social science methodologies in their research. Qualitative methods have been discussed in recent workshops in veterinary epidemiology conferences (e.g. Society for Veterinary Epidemiology and Preventive Medicine, 2011 & 2014). There is indeed much scope for 'mess amongst disciplines' (Donaldson *et al.*, 2010) and creating synergies by moving across the divide between the social and natural sciences. With a foot in both camps I have proven that it is possible. For policy makers, this may require 'rethinking some central assumptions about the role of natural and social sciences in real-world policy design' (Fish *et al.*, 2011: 2033). The rewards are rich for all concerned, and there is much potential for geographers to have impact outside of the confines of academia (Pain *et al.*, 2011).

Geography speaks to policy

What then to say from geography and the academy to policy with respect to TB? Firstly, there is a need to make TB *visible* again. Ironically, I suggest that the eradication programme has become a victim of its own success – the lack of a visible TB presence on farms in terms of clinical cases (wasting, coughing, dying cattle) in NI has rendered the disease invisible to farmers (and vets). Its impacts are uneven across farms – some see it, others don't, and to varying degrees of impact within herds. Some question whether its presence is 'real'. The need for visibility was recognised in the very earliest efforts to eradicate TB in both humans and animals in early 20th century America, as mentioned in Chapter 8. Likewise, Lady Aberdeen (1857-1939), who organised a campaign against human TB in Ireland, began with an exhibition in Dublin in October 1907 (Breathnach & Moynihan, 2012). It moved north in December 1907, visiting Belfast, Lisburn and Lurgan before being taken around Ireland by horse-drawn caravan (Breathnach & Moynihan, 2012). The aim was to make TB *visible*. Today's generation of farmers have forgotten what TB in cattle looks or sounds like – it is merely a lumpy swelling on the side of the neck. There is nothing else to see until the carcass is opened, and even then early lesions may remain hidden from view.

Secondly, there is a need for clarification of what the programme is aiming to achieve in terms of *eradication* or *control*. Throughout this thesis the word 'eradication' has been used unproblematically. In the common everyday use of the word it simply means to 'destroy' or 'wipe out'. This is the word which EU legislation uses to demand how TB must be dealt with, and it is also what the TB programme in NI is known by – it is a TB *eradication* programme. And yet the concept and route to eradication is more complex than first appears. At present there are uncertainties which could be called the 'uncertainties of alleviation' (Fish *et al.*, 2011: 2031) – how to deal with the threat. From my interviews it is clear that the farming population does not believe eradication is a realizable goal given the history of the programme, and despite the legislative demands and political rhetoric of eradication rather than control, *control* wins the day amongst the majority of the vets that I interviewed. Vets believe that given the complex political economy and ecologies of the disease in NI, and with a continuation of the existing programme methodologies, eradication is, at best, a *long-term* rather than a short-term or even medium-term objective. The great hope for significant progress amongst farmers and their representatives is badger culling; the hope for vets is to see a cattle vaccine or a better diagnostic test being developed through technological progress. The overall objective, becoming Officially Tuberculosis-Free (OTF), means that an EU Member State must have no more than 0.1% of its herds with TB, and at least 99.9% of herds with OTF status each year for six consecutive years (EEC, 1964). That is a very difficult challenge, and the current situation is quite a long way from reaching the target.

To do so, TB eradication efforts require a delicate balancing act, and Fish *et al.* (2011), while not focusing on TB specifically, show that a commitment to reduce or eradicate disease involves a plurality of other considerations. For example, they argue that any such efforts must consider minimal duration of effort; minimal burden on industry; cost efficiency; and sharing responsibility. In other words, there is always a juggling of priorities and feasibilities. Not everything is being done that could potentially be done on TB, because the industry needs to remain commercially viable and politicians are wary of pushing too hard. This was recognised by the farmers in my focus group when they reacted adversely to my hypothetical scenario of more severe controls on TB-restricted herds:

> Farmer 2: 'You would be at the stage of cure the disease but kill all the patients, you know. Some of those things could be thought about if you had these AFUs (Approved Fattening Units) ... You could think of *some* of those things - not all of them, but you could think of some of them //'
>
> Farmer 1: '// Otherwise men had better pull the pin.' (Int A58, farmer focus group)

There was therefore a bargaining response – some added measures, but not all, for fear of the medicine being worse than the condition, and doubts about whether it would be viable to continue if the balance was wrong. Eradication, though, is not a bargain – it is all or nothing.

It is not unusual to have doubts in longstanding disease eradication programmes. Celebrating India's certification as being polio-free, a director of the Global Polio Eradication Initiative said that in addition to ensuring every child was vaccinated, the most important factor was 'believing, unwaveringly, that the job could be completed' (Maurice, 2014: 939). For TB, the belief is currently lacking, and an open and honest appraisal needs to begin about what the programme plans (or rather, hopes) to achieve over the next 5, 10 and 20 years. Setting targets may provide definite goals to aim for, and a sense of purpose for the programme. By way of example, England's target is to eradicate TB by 2038 (DEFRA, 2014).

Thirdly, the programme and its participants must be able to accept *heterogeneity*. TB is not a predictable entity, and its transmissions are often surprising. Not every herd or animal will be infected when challenged and not every herd or animal will develop a positive immune response to the presence or past exposure to TB when tested. This behaviour confuses farmers and encourages them to adopt fatalistic scripts about TB being uncontrollable. To some extent it is, but there *are* biosecurity measures that can be adopted by farmers to try to reduce the risk of TB incursion into their herds, but the same prescribed methods may not work on every farm. There is also heterogeneity amongst farmers – they do not speak as one, and they felt that their representative organizations and local politicians did not represent the diversity of views and opinions that they hold. There are differences in outlook between full-time and part-time, between dairy and beef; UFU members and those who are not; and between individuals even within these sectors. For example, the future looked bleak for most of the beef farmers I interviewed, but the reverse was true amongst the dairy farmers (Chapter 4). As Dawson (1997) suggested nearly two decades ago, there must be an appreciation of *diversity* rather than uniformity when considering the outlooks and responses to change amongst Northern Irish family farmers. The challenge is to develop new and various ways to communicate with the diversity of opinion within the cattle industry. Not everyone will read the contents of the brown paper envelope containing the latest biosecurity advice from DARD. They are much more likely to listen to the advice of their farming neighbour or dairy network (Chapter 4).

Fourthly, the programme also needs to acknowledge and account for the *indeterminacy* and *uncertainty* of coping with TB. This approach 'emphasizes that … networks of complex social and technological systems, such as disease containment, are often open, emergent and highly context specific, and therefore consistently defy prediction and control' (Fish *et al.*, 2011: 2027). In such systems, uncertainties abound. For example, there needs to be more open acceptance of the failings of the tuberculin skin test. In addition to the inherent weaknesses and failings of humans in performing any task, even to the best of their intentions and ability, the latencies and anergies of the bacterium combined with the moderate sensitivity of the test mean that a proportion of infected animals will remain undetected, even with repeated testing. As Wynne (2007) explains, public (and for 'public' substitute 'farmer') concerns may relate to the *science* of the matter and not only those who wield power as experts or regulators. In the case of TB, mistrust extends beyond the relationships between farmers and vets and the state, but centres on the TB test, perhaps the 'exaggeration of control and predictive capacity … [and] its unrealism about or denial of relevant contingencies' (Wynne 2007: 105). The science of TB has consistently shown itself to be indeterminate and uncertain. The merits (or otherwise) of badger culling as an effective control policy, and transmission pathways between badgers and bovines, are typical examples.

Fifthly, although animal disease control may appear to be primarily about animals, it is arguably more about relationships between *people*. There is therefore a need for the state to *re-engage* with the farmers as people, not statistics, to rebuild trust, broaden vision, and promote reconciliation and partnership. Conversely, farmers and vets need to re-engage with state officials as people of good will and purpose, not viewing the state as an ephemeral entity exercising disease control authority with malicious intent. Broken and strained relationships need to be repaired, and marginalization avoided. State regulation and its corollary - resistance to statutory authority - have produced division between opposing sides and a conflict situation. Many farmers are not enrolled in the effort to eradicate the disease, and many are reluctant to take ownership of the problem. Efforts to encourage farmers to adopt better farm biosecurity against TB have largely failed. Leach *et al.* (2010) described this effect in relation to Ebola and the response to highly-pathogenic avian influenza (HPAI), with governance interventions being derailed by perceived injustice on the ground.

Rather like the 'public deficit model', whereby the task of policy makers and scientists is to educate and thereby persuade a public lacking in the knowledge necessary to accept and enact, there is a commonly held view that farmers merely need to be better educated and more informed about biosecurity to reduce the implementation gap. This is not necessarily the case – more knowledge does not guarantee implementation. Alternatively, better engagement opens the door to co-production of solutions to TB, taking due cognisance to the ingenuity and adaptability of lay expertise of farmers, and professional expertise of vets, in problem-solving at ground level. This involves co-opting local knowledge – defined by Fish *et al.* (2011:2032) as 'bodies of expertise tied to the experience of disease in particular places and locales' – and it includes both farmers and their veterinary practitioners. Co-produced disease control strategies 'are likely to result in stronger trust between actors, required levels of compliance, and ultimately, better impact on human and animal welfare' (Catley *et al.*, 2012: 158). As political ecologist Mara Goldman (2007: 313) argues, the focus can be shifted to 'building dialogues across knowledge spaces and between different knowledge participants', drawing together lay and expert knowledges in places of mutual respect. Adopting lay expertise does not envisage or expect the public to provide 'competence to deal directly with specialist technical questions' (Wynne, 2007: 107), but it does mean dealing with and influencing the *social* aspects of the problem, usually ignored or suppressed in normative stakeholder encounters.

I would suggest that this not only involves engaging with farming representative bodies such as the UFU, but also, and perhaps more importantly, directly engaging with farmers individually and collectively. There is a need to listen 'to voices that do *not* contribute to formal policy-making ... to take into account the decisions and actions being made by others on the ground *outside* the formal policy process [*emphasis in original*]' (Blaikie, 2009: 5). In doing so, the state must consider the difficult economic conditions within which farmers are operating. In turn, farmers must be willing to trust the goodwill of the state in its efforts to eradicate TB for both their individual benefit and the future safeguarding of their industry within the confines of their statutory obligations.

Sixthly, there must be a '*rescaling* of [the] objects and agents of *governance*' (Bulkeley, 2005: 875) to produce 'new geographies of governance' (Bulkeley, 2005: 882). Could it be possible that governance is rescaled to 'emanate from the 'bottom up'' (Bulkeley, 2005: 879)? Farmers are agents of governance at ground level, but they probably do not see themselves as such. Farmers were not keen to see governance of the TB programme pass to themselves or to representative farming bodies such as the UFU. Instead, they felt that the state was best placed to direct the operationalization of the programme and to 'police' the stakeholders involved more effectively. But in a new model of network governance, farmers would take much more responsibility for governing TB across varying scales. The crux of the problem is how to stop *M. bovis* from being mobile – to halt its progress between individual cattle; between herds and farms; between badgers and cattle and vice versa; to *immobilize* the bacterium. If the mobility of the bacterium was reduced, the number of outbreaks of TB would also be reduced, and the liveliness of this 'troubling' mobility (Cresswell, 2014) would be curbed.

At the scale of the microscopic, farmers would control TB bacteria through cleansing and disinfection to kill bacteria contaminating infected sheds after TB reactors have been removed for slaughter. At the level of the bovine body they would isolate test reactor and inconclusive animals as required to do so by law. They would seek to refrain from purchasing livestock, but if they do, they will buy them from known herds with a history of TB-freedom and have them privately tested for TB before release into the herd. At herd level, they will avoid grazing their cattle in 'infected places' – places where TB has a history of presence. At a local level, network governance will mean farmers will work with others to reduce TB at the levels of townlands and local districts by avoiding grazing cattle on farm boundaries, away from other contiguous herds and potential sources of infection. Farmers may even begin to govern themselves: 'Social comparison and peer pressure work better than any lecture on how one should behave,' states Oullier (2013: 463). There is a case for the state to organize county TB eradication committees based on the old model of County Agricultural Committees including participation by farmers and vets alongside state officials and politicians, creating 'regional assemblages' with a wider range of actors working together with common purpose (Allen & Cochrane, 2010: 1081).

There is also a need to see TB as a multiscalar problem - local, regional, national and international. At the local level, its causes and effects are in individual animals and herds. Scaling up, the effects of TB are both regional and national, within NI but also affecting the UK's European and international standing with respect to animal health, potentially affecting global export markets. Farmers seldom think of the national consequences of TB incidence, but they do think about the TB incidence in their own herd. If they have no TB in their herd, there is generally no interest in the disease, and with around 94% of herds free of the disease, the vast majority is not prioritizing TB on a list of threats to farm business security. In turn, the state thinks primarily about the scaled-up consequences of TB incidence for EU funding of the programme and the protection of export trade. As a result, there is a divergence of aspiration and ambition, with farmers failing to see the bigger picture beyond their own farm business, and perhaps the state failing to grasp enough of an understanding of the effects of TB at the farm level, although they may attempt to do so.

Seventh, and finally, the *economic benefits* of even maintaining the status quo of TB *control* must be highlighted. Given the vibrant ecologies of the bacterium, the forgotten actor at the centre of this complex and tortuous problem, I suggest that control is an achievement not to be underestimated and undervalued, when the endgame of eradication of TB is still years, even decades away. If the TB programme is to adopt innovation and radical change, whatever that may be, there surely needs to be a 'full and serious open-minded process of appraisal of not just risks, but of benefits-claims and promises, and of alternatives' (Wynne, 2007: 106). The problem is that not everyone sees the benefit of engaging or making progress, as Blaikie (1985: 98) concluded in a different context: 'States have seen fit to try and persuade, induce or coerce the people to undertake new patterns of ... agricultural practice. One of the major problems with this is that the private benefits accruing to households or families who take up ... [the] measures are often not clear – either as perceived to exist by households themselves or even as calculated by economic models'. Whilst in no way belittling the suffering of those chronically and severely affected by TB outbreaks in their herds, I suggest that the farming stakeholders involved in TB do not see the current programme's success in maintaining global markets for NI produce, at considerable financial cost to the state and its taxpayers.

If the human actors involved in TB control cannot agree to break down walls of separation to come together in a network governance approach between the state and the markets, the markets may change the governance of TB through their own power in the assemblage. Hall (2010) reports the rise of private governance in world markets, particularly by powerful retailers, who dictate the standards of food which they retail for the consumer market. Should domestic and international purchasers become more concerned about the disease status of the animals which supply their milk and beef, a whole new governance structure could emerge in setting the standards for TB in NI.

The process has already begun to a limited extent, with at least one dairy in NI requiring that all of its milk supply comes from herds free of TB. Similarly, an investigation into the price disparity between beef cattle values in GB compared to NI argued that the export market from NI to GB was not functioning to its full potential (Oxford Economics, 2012). The report went on to conclude that 'TB incidence is a significant trade barrier in exporting cattle for direct slaughter in GB' (Oxford Economics, 2012: 56). As with the change in conditions affecting exports to GB in the 1950s drove the TB eradication programme in its formative years (Chapter 3), so a rise in private governance standards from powerful conglomerates of processors and retailers could exert more persuasion to control TB at both the macro- and micro-levels, perhaps more effectively than any state could ever do. Just as the consumer and the market which fulfils consumer demand required the eradication of BSE (Smith *et al.*, 2004), so the market may one day demand the speedier eradication of TB in order to continue trading.

Currently, farmers are willing to accept the risk of TB when purchasing animals partly because of the lack of price differential in produce from TB-affected herds. But as Grant (2012: 276) explains, retailer governance can operate on an altogether different premise: 'If you don't comply, you can't supply'. The state's role may become largely administrative, and will no longer be one of persuading and cajoling; the markets will perform that role instead and almost certainly to more effect. Market forces may have more power than any member of the present assemblage of humans concerned with TB eradication. It would be interesting to postulate whether a new economic landscape might change attitudes to eradication, and if that would re-focus minds on targeting an 'endgame' (Klepac *et al.*, 2013) for TB.

Final words

Control, whilst extremely valuable in keeping open export markets and reducing the health threat to animals and humans, can be improved upon, and it should be possible to edge ever closer to eradication. Without vision and hope for the future, even the fragile grip of control can quickly be lost. This needs to be 'hope with its sleeves rolled up' (Swaisgood & Sheppard, 2011: 427). Many years of toiling like Sisyphus has brought fatigue, and in many quarters, apathy. As a result, renewed effort and aspiration for the long-term from all involved in the TB governance network is required, but the glass is half full, not half empty. This requires effective and visionary leadership from the state, veterinary and farming communities. Farmers and vets must be ready to step up and play their part in network governance, and the state must be willing to show leadership but also be willing to cede some of their power for the good of the network. Network governance can be authoritative and persuasive, contends Hajer (2009: 4), but requires 'leaders … to perform in situations that are partly beyond their control'.

The chain of explanation links back to a place for the scientific laboratory in the TB assemblage. Although Moore and Kosut (2013: 21) encourage practising intra-species mindfulness, they remind us that 'animals [and to that we could add *microbes*] have a world that is unknown to us'. There is still much that is unknown about the practices of *M. bovis* at the scale of the microscopic, and with its endless capacity to surprise, even control (never mind *eradication*) is going to remain very challenging indeed; but that does not mean that we give up. Future research on the benches and in the fume cupboards of laboratories might open up new vistas and give hope of brighter days to come through the development of new diagnostic technologies (Casal *et al.*, 2014); TB vaccines (Buddle *et al.*, 2013); or further uncovering genetic markers to allow selective breeding for resistance (Allen *et al.*, 2010).

There is also a need to 'linger in the space of the [bacterium]' (Moore & Kosut, 2013: 2) and to study more of what van Loon (2005: 39) calls the 'uncharted zones between the microphysics of infection and the macrophysics of epidemics'. The aim in doing so is to attempt to keep one step ahead of a remarkably persistent contagion, mindful that these microbes 'adhere to different topologies and comprise non-human mobilities, which frequently do not conform to the territories and networks familiar to humans' geographies' (Hodgetts & Lorimer, 2014: 7). The danger of over-emphasizing respect for the 'radical alterity and unpredictability of organisms [and] their ecologies' in what Lorimer calls the 'vibrant strand of political ecology' may result in 'appeals for flourishing and conviviality [which] are vague and context-specific. They do not offer general ethical frameworks or overarching structural causes' (Lorimer, 2012: 604). On the other hand, ignoring or underestimating the liveliness and vibrancy of matter (Bennett, 2010) is also problematic. As Lorimer (2012: 606) counterbalances his argument, he affirms that 'targets, icons and action plans are necessary, but they should give scope for non-human dynamics, multispecies deliberation and experimentation and forms of adaptive management'.

In the meantime all the human actors need to collaboratively [net]work together and stop blaming each other for the failure to completely curb the spread of this 'recalcitrant microbe' (Latour, 2000: 116). As with ongoing efforts to eradicate polio: 'The way forward is not to abandon hope about the ends but to be more realistic about the means. There are no simple solutions to the complexities of implementation ... but dealing with these complexities requires open, frank discussion' (Closser, 2012: 399).

Too many cattle have had to be tested and slaughtered, and too much money has been spent over many years to give up now; conceding defeat is surely not an option. Nonetheless, changes must be made to the programme and its governance in order to move closer towards the goal of eradication. Only then may we (perhaps) declare that 'it is now apparent that tuberculosis in cattle is a disease which lends itself to practical control measures' (MANI, 1951: 270). This thesis begins the open, frank discussion. Others must carry forward its findings to innovative and collective implementation on the ground.

References

Abel, N. & Blaikie, P. (1986) Elephants, people, parks and development: the case of the Luangwa Valley, Zambia. *Environmental Management*, 10, 735-751.

Abernethy, D.A. (2008) The epidemiology and management of bovine brucellosis in Northern Ireland. Unpublished PhD thesis, Royal Veterinary College, University of London.

Abernethy, D.A., Pfeiffer, D.U. & Neill, S.D. (2000) Case control study examining the role of livestock markets in the transmission of bovine tuberculosis. In: Society for Veterinary Epidemiology and Preventive Medicine Proceedings. Eds. Thrushfield, M.V. & Goodall, E.A. Edinburgh, 29–31 March 2000. pp. 108–114.

Abernethy, D.A., Denny, G.O., Menzies, F.D., McGuckian, P., Honhold. N. & Roberts, A.R. (2006) The Northern Ireland programme for the control and eradication of *Mycobacterium bovis*. *Veterinary Microbiology*, 112, 231-237.

Adey, P. (2006) If mobility is everything then it is nothing: towards a relational politics of (im)mobilities. *Mobilities*, 1, 75-94.

Adey, P. (2010) *Mobility*. Routledge: London & New York.

Adey, P. & Anderson, B. (2011) Anticipation, materiality, event: the Icelandic ash cloud disruption and the security of mobility. *Mobilities*, 6, 11-20.

Agrawal, A. (2005) *Environmentality: technologies of government and the making of subjects*. Duke University Press: Durham, NC & London.

Agri-Food Strategy Board (2013) Going for growth: a strategic action plan in support of the Northern Ireland Agri-Food industry. Available online at: http://www.agrifoodstrategyboard.org.uk/uploads/Going%20for%20Growth%20-%20Web%20Version.PDF Accessed 23 October 2013.

Aistara, G.A. (2009) Maps from space: Latvian organic farmers negotiate their place in the European Union. *Sociologia Ruralis*, 49, 132-150.

Ali, S.H. & Keil, R. (2008) *Networked disease: emerging infections in the global city*. Wiley-Blackwell: Malden, Oxford & Chichester.

Allen, J. & Cochrane, A. (2010) Assemblages of state power: topological shifts in the organization of government and politics. *Antipode*, 42, 1071-1089.

Allen, A.R., Minozzi, G., Glass, E.J., Skuce, R.A., McDowell, S.W.J., Woolliams, J.A. & Bishop, S.C. (2010) Bovine tuberculosis: the genetic basis of host susceptibility. *Proceedings of the Royal Society B,* 277, 2737-2745.

Amos, W., Brooks-Pollock, E., Blackwell, R., Driscoll, E., Nelson-Flower, M. & Conlan, A.J.K. (2013) Genetic predisposition to pass the standard SICCT test for bovine tuberculosis in British cattle. *PLOS One*, 8, 3, e58245.

Anderson, B. (2006) Becoming and being hopeful: towards a theory of affect. *Environment and Planning D: Society and Space*, 24, 733-752.

Anderson, B. (2010) Preemption, precaution, preparedness: anticipatory action and future geographies. *Progress in Human Geography*, 34, 777-798.

Anderson, J. & Jones, K. (2009) The difference that place makes to methodology: uncovering the 'lived space' of young people's spatial practices. *Children's Geographies*, 7, 291-303.

Anderson, B. & McFarlane, C. (2011) Assemblage and geography. *Area*, 43, 124-127.

Anderson, B., Kearnes, M., McFarlane, C. & Swanton, D. (2012) Materialism and the politics of assemblage. *Dialogues in Human Geography*, 2, 212-215.

Anon (2005) *The Merck veterinary manual: 9th edition*. Eds, Kahn, C.M. & Line, S. Merck & Co. Inc: Whitehouse Station, NJ.

Armstrong, D.L. (1989) *An economic history of agriculture in Northern Ireland, 1850-1900*. Plunkett Foundation for Co-Operative Studies: Oxford.

Armstrong, J. (2011) Veterinary expertise. Unpublished PhD thesis, School of Agriculture, Newcastle University.

Atkins, P.J. (1988) Redefining agricultural geography as the geography of food. *Area*, 20, 281-283.

Atkins, P. (2007) Laboratories, laws, and the career of a commodity. *Environment and Planning D: Society and Space*, 25, 967-989.

Atkins, P.J. (2010) Lobbying and resistance with regard to policy on bovine tuberculosis in Britain, 1900-1939: an inside/outside model. In: *Tuberculosis then and now: perspectives on the history of an infectious disease*. Eds. Condrau, F. & Worboys, M. McGill-Queen's University Press: Montreal, Kingston, London & Ithaca. pp. 189-212.

Atkins, P.J., Hassan, M.M. & Dunn, C.E. (2007) Environmental irony: summoning death in Bangladesh. *Environment and Planning A*, 39, 2699-2714.

Atkins, P.J. & Robinson, P.A. (2013a) Coalition culls and zoonotic ontologies. *Environment and Planning A*, 45, 1372-1386.

Atkins, P.J. & Robinson, P.A. (2013b) Bovine tuberculosis and badgers in Britain: relevance of the past. *Epidemiology and Infection*, 141, 1437-1444.

Bakker, K. (2004) *An uncooperative commodity: privatizing water in England and Wales*. Oxford University Press: Oxford.

Bakker, K. (2012) Water: political, biopolitical, and material. *Social Studies of Science*, 42, 616-623.

Bakker, K. & Bridge, G. (2006) Material worlds? Resource geographies and the 'matter of nature'. *Progress in Human Geography*, 30, 5-27.

Balseiro, A., Rodriguez, O., González-Quiros, P., Merediz, I., Sevilaa, I.A., Davé, D., Dalley, D.J., Lesellier, S., Chambers, M.A., Bezos, J., Munoz, M., Delahay, R.J., Gortázar, C. & Prieto, J.M. (2011) Infection of Eurasian badgers (*Meles meles*) with *Mycobacterium bovis* and *Mycobacterium avium* complex in Spain. *The Veterinary Journal*, 190, e21-e25.

Bang, B. (1908) Measures taken against animal tuberculosis in Denmark. *The Journal of Comparative Pathology and Therapeutics*, 21, 287-303.

Bardach, E., & Kagan, R. (1982) *Going by the book: the problem of regulatory unreasonableness*. Philadelphia: Temple University Press.

Barnes, J.A. (1979) *Who should know what?* Cambridge University Press: Cambridge, London, New York, New Rochelle, Melbourne & Sydney.

Batterbury, S.P.J. (1996) Planners or performers? Reflections on indigenous dryland farming in Northern Burkina Faso. *Agriculture and Human Values*, 13, 12-22.

Batterbury, S. (2001) Landscapes of diversity: a local political ecology of livelihood diversification in south-western Niger. *Ecumene*, 8, 437-464.

Batterbury, S.P.J. & Fernando, J.L. (2006) Rescaling governance and the impacts of political and environmental decentralization: an introduction. *World Development*, 34, 1851-1863.

Batterbury, S., Forsyth, T. & Thomson, K. (1997) Environmental transformations in developing countries: hybrid research and democratic policy. *The Geographical Journal*, 163, 126-132.

Baxter, J. & Eyles, J. (1997) Evaluating qualitative research in social geography: establishing 'rigour' in interview analysis. *Transactions of the Institute of British Geographers*, 22, 505-525.

Baxter, J. & Eyles, J. (1999) The utility of in-depth interviews for studying the meaning of environmental risk. *Professional Geographer*, 51, 307-320.

Bear, C. (2012) Assembling the sea: materiality, movement and regulatory practices in the Cardigan Bay scallop fishery. *Cultural Geographies*, 20, 21-41.

Beisel, U. (2010) Jumping hurdles with mosquitoes? *Environment and Planning D: Society and Space,* 28, 46-49.

Benjamin, L.A., Fosgate, G.T., Ward, M.P., Roussel, A.J., Feagin, R.A. & Schwartz, A.L. (2010) Attitudes towards biosecurity practices relevant to Johnes disease control on beef cattle farms. *Preventive Veterinary Medicine,* 94, 222-230

Benjaminsen, T.A., Aune, J.B. & Sidibé, D. (2010) A critical political ecology of cotton and soil fertility in Mali. *Geoforum*, 41, 647-656.

Bennett, K. (2004) Emotionally intelligent research. *Area*, 36, 414-422.

Bennett, K. (2006) Kitchen drama: performances, patriarchy, and power dynamics in a Dorset farmhouse kitchen. *Gender, Place and Culture,* 13, 153-160.

Bennett, J. (2010) *Vibrant matter: a political ecology of things*. Duke University Press: Durham, NC & London.

Bernstein, H. (2010) Introduction: some questions concerning the productive forces. *Journal of Agrarian Change*, 10, 300-314.

Bickerstaff, K. & Simmons, P. (2004) The right tool for the job? Modelling, spatial relationships, and styles of scientific practice in the UK foot and mouth crisis. *Environment and Planning D: Society and Space*, 22, 393- 412.

Bidwell, D. (2010) Bison, boundaries, and brucellosis: risk perception and political ecology at Yellowstone. *Society and Natural Resources*, 23, 14-30.

Biehler, D.D. (2009) Permeable homes: a historical political ecology of insects and pesticides in US public housing. *Geoforum*, 40, 1014-1023.

Biek, R., O'Hare, A., Wright, D., Mallon, T., McCormick, C., Orton, R.J., McDowell, S., Trewby, H., Skuce, R.A. & Kao, R.R. (2012). Whole genome sequencing reveals local transmission patterns of *Mycobacterium bovis* in sympatric cattle and badger populations. *PLOS Pathogens*, 8, 11, e1003008. doi:10.1371/journal.ppat.1003008.

Bienen, L. & Tabor, G. (2006) Applying an ecosystem approach to brucellosis control: can an old conflict between wildlife and agriculture be successfully managed? *Frontiers in Ecology and the Environment*, 4, 319-327.

Billo, E. & Hiemstra, N. (2013) Mediating messiness: expanding ideas of flexibility, reflexivity, and embodiment in fieldwork. *Gender, Place and Culture*, 20, 313-328.

Bingham, N. (2003) Writing reflexively. In: *Using social theory: thinking through research*. Eds. Pryke, M., Rose, G. & Whatmore, S. SAGE Publications Ltd.: London, Thousand Oaks & New Delhi. pp. 145-162.

Bingham, N. (2008) Slowing things down: lessons from the GM controversy. *Geoforum*, 39, 111-122.

Black, R. (1990) 'Regional political ecology' in theory and practice: a case study from northern Portugal. *Transactions of the Institute of British Geographers*, 15, 35-47.

Blaikie, P. M. (1975) *Family planning in India: diffusion and policy*. Edward Arnold (Publishers) Ltd: London.

Blaikie, P. (1985) *The political economy of soil erosion in developing countries*. Longman: London & New York.

Blaikie, P. (1989) Explanation and policy in land degradation and rehabilitation for developing countries. *Land Degradation and Rehabilitation*, 1, 23-37.

Blaikie, P. (1995) Understanding environmental issues. In: *People and Environment*. Eds. Morse, S. & Stocking, M. UCL Press: London. pp. 1-30.

Blaikie, P. (1996) Post-modernism and global environmental change. *Global Environmental Change*, 6, 81-85.

Blaikie, P. (2001) Social nature and environmental policy in the South: views from verandah and *veld*. In: *Social nature: theory, practice, and politics*. Eds. Castree, N. & Braun, B. Blackwell Publishing : Malden, Oxford & Carlton. pp. 133-150.

Blaikie, P. (2008) Epilogue: towards a future for political ecology that works. *Geoforum*, 39, 765-772.

Blaikie, P. (2009) The tsunami of 2004 in Sri Lanka: an introduction to impacts and policy in the shadow of civil war. *Norsk Geografisk Tidsskrift – Norwegian Journal of Geography*, 63, 2-9.

Blaikie, P. (2012) Should some political ecology be useful? The inaugural lecture for the Cultural and Political Ecology Specialty Group, Annual Meeting of the Association of American Geographers, April 2010. *Geoforum*, 43, 231-239.

Blaikie, P. & Brookfield, H. (1987) *Land degradation and society*. Methuen: London & New York.

Blaikie, P. & Springate-Baginski, O. (2007) Setting up key policy issues in participatory forest management. In: *Forests, people and power: the political ecology of reform in South Asia*. Eds. Springate-Baginski, O. & Blaikie, P. Earthscan: London & Sterling, VA. pp. 1-23.

Blaikie, P., Brown, K., Stocking, M., Tang, L., Dixon, P. & Sillitoe, P. (1997) Knowledge in action: local knowledge as a development resource and barriers to its incorporation in natural resource research and development. *Agricultural Systems*, 55, 217-237.

Böhm, M., Palphramand, K.L., Newton-Cross, G., Hutchings, M.R. & White, P.C.L. (2008) Dynamic interactions among badgers: implications for sociality and disease transmission. *Journal of Applied Ecology*, 77, 735-745.

Bourdieu, P. (1988) *Homo academicus*. Trans. by Collier, P. Stanford University Press: Stanford, CA.

Bourget, M-N., Licoppe, C. & Sibum, H.O. (2002) Introduction. In: *Instruments, travel and science: itineraries of precision from the seventeenth to the twentieth century*. Routledge: London & New York. pp. 1-19.

Bowler, I. (1985) Some consequences of the industrialization of agriculture in the European Community. In: *The industrialization of the countryside*. Eds. Healey, M.J. & Ilbery, B.W. Short Run Press Ltd: Norwich. pp. 75-97.

Boyd, W., Prudham, W.S. & Schurman, R. (2001) Industrial dynamics and the problem of nature. *Society and Natural Resources*, 14, 555-570.

Braun, B. (2008) Environmental issues: inventive life. *Progress in Human Geography,* 32, 667-679.

Braun, B. (2011) Governing disorder: biopolitics and the molecularization of life. In: *Global political ecology*. Eds. Peet, R., Robbins, P. & Watts, M. Routledge: London & New York. pp. 389-411.

Braun, B. & Whatmore, S. (2010) *Political matter: technoscience, democracy, and public life*. University of Minnesota Press: Minneapolis & London.

Breathnach, C.S. & Moynihan, J.B. (2012) The frustration of Lady Aberdeen in her crusade against tuberculosis in Ireland. *Ulster Medical Journal*, 81, 37-47.

Bridge, G. (2011) The economy of nature: from political ecology to the social construction of nature. In: *The SAGE handbook of economic geography*. Eds. Leyshon, A., Lee, R., McDowell, L. & Sunley, P. SAGE: Los Angeles, London, New Delhi, Singapore & Washington D.C. pp. 217 – 230.

Bridge, G. & Perreault, T. (2009) Environmental governance. In: *A companion to environmental geography*. Eds. Castree, N., Demeritt, D., Liverman, D. & Rhoads, B. Blackwell Publishing Ltd: Malden, Oxford & Chichester. pp. 475-497.

Brookfield, H. (2008) Family farms are still around: time to invert the old agrarian question. *Geography Compass*, 2, 108-126.

Brown, J.C. & Purcell, M. (2005) There's nothing inherent about scale: political ecology, the local trap, and the politics of development in the Brazilian Amazon. *Geoforum*, 36, 607-624.

Brown, S.P. & Buckling, A. (2008) A social life for discerning microbes. *Cell,* 135, 600-603.

Bryant, R.L. & Bailey, S. (1997) *Third world political ecology*. Routledge: London & New York.

Buddle, B.M., Parlane, N.A., Wedlock, D.N. & Heiser, A. (2013) Overview of vaccination trials for control of tuberculosis in cattle, wildlife and humans. *Transboundary and Emerging Diseases*, 60, 136-146.

Buijs, A.E., Arts, B.J.M., Elands, B.H.M. & Lengkeek, J. (2011) Beyond environmental frames: the social representation and cultural resonance of nature in conflicts over a Dutch woodland. *Geoforum*, 42, 329-341.

Bulkeley, H. (2005) Reconfiguring environmental governance: towards a politics of scales and networks. *Political Geography*, 24, 875-902.

Bull, J. (2011a) Encountering fish, flows, and waterscapes through angling. *Environment and Planning A*, 43, 2267-2284.

Bull, J. (2011b) *Animal movements, moving animals: essays on direction, velocity and agency in humanimal encounters*. Centre for Gender Research, Uppsala University: Uppsala.

Buller, H. (2008) Safe from the wolf: biosecurity, biodiversity, and competing philosophies of nature. *Environment and Planning A*, 40, 1583-1597.

Burgess, J., Limb, M. & Harrison, C.M. (1988) Exploring environmental values through the medium of small groups: 1. Theory and practice. *Environment and Planning A*, 20, 309-326.

Büscher, M., Goodwin, D. & Mesman, J. (2010) Ethnographies of diagnostic work: introduction. In: *Ethnographies of diagnostic work: dimensions of transformative practice*. Eds. Büscher, M., Goodwin, D. & Mesman, J. Palgrave Macmillan: Basingstoke. pp. 1-14.

Butz, D. (2010) Autoethnography as sensibility. In: *The SAGE handbook of qualitative geography*. Eds. DeLyser, D., Herbert, S., Aitken, S., Crang, M. & McDowell, L. SAGE: Los Angeles, London, New Delhi, Singapore & Washington DC. pp. 138-155.

Byrne, A.W., Quinn, J.L., O'Keefe, J.J., Green, S., Sleeman, D.P., Martin, S.W. & Davenport, J. (2014) Large-scale movements in European badgers: has the tail of the movement kernel been underestimated? *Journal of Animal Ecology*, published early view online at doi: 10.1111/1365-2656.12197.

Callon, M. (1986) Some elements of a sociology of translation: domestication of the scallop and the fishermen of St Brieuc Bay. In: *Power, action and belief: a new sociology of knowledge?* Routledge & Kegan Paul plc: London & Boston. pp. 196-233.

Callon, M. (1998) An essay on framing and overflowing. In: *The laws of the markets*. Ed. Callon, M. Blackwell Publishers/The Sociological Review: Oxford & Malden, MA. pp. 244-269.

Callon, M., Law, J. & Rip, A. (1986) *Mapping the science and dynamics of science and technology: sociology of science in the real world*. The Macmillan Press Ltd: Basingstoke & London.

Callon, M., Lascoumes. P. & Barthe, Y. (2011) *Acting in an uncertain world: an essay on technical democracy*. Trans. by Burchell, G. The MIT Press: Cambridge, MA & London.

Cameron, J. (2010) Focusing on the focus group. In: *Qualitative research methods in human geography*. Ed. Hay, I. Oxford University Press: Ontario. pp. 152-172.

Campbell, L.M. (2011a) Debating the science of using marine turtles. In: *Knowing nature: conversations at the intersection of political ecology and science studies*. Eds. Goldman, M.J., Nadasdy, P. & Turner, M.D. University of Chicago Press: Chicago & London. pp. 47-64.

Campbell, T.C. (2011b) *Improper life: technology and biopolitics from Heidegger to Agamben*. University of Minnesota Press: Minneapolis & London.

Campbell, L.M., Gray, N.J., Meletis, Z.A., Abbott, J.G. & Silver, J.J. (2006) Gatekeepers and keymasters: dynamic relationships of access in geographical fieldwork. *The Geographical Review*, 96, 97-121.

Canguilhem, G. (1978) *On the normal and the pathological*. Trans. by Fawcett, C.R. Reidel Publishing Company: Dordrecht, Boston & London.

Casal, C., Díez-Guerrier, A., Álvarez, J., Rodriguez-Campos, S., Mateos, A., Linscott, R., Martel, E., Lawrence, J.C., Whelan, C., Clarke, J., O'Brien, A., Dominguez, L. & Aranaz, A. (2014) Strategic use of serology for the diagnosis of bovine tuberculosis after intradermal skin testing. *Veterinary Microbiology*, 170, 342-351.

Cassidy, A. (2012) Vermin, victims and disease: UK framings of badgers in and beyond the bovine TB controversy. *Sociologia Ruralis*, 52, 192-214.

Cassidy, J.P., Bryson, D.G., Pollock, J.M., Evans, R.T., Forster, F. & Neill, S.D. (1999) Lesions in cattle exposed to *Mycobacterium bovis*-inoculated calves. *Journal of Comparative Pathology*, 121, 321-337.

Castree, N. (2005) *Nature*. Routledge: Abingdon & New York.

Castree, N. & Braun, B. (1998) The construction of nature and the nature of construction: analytical and political tools for building survivable futures. In: *Remaking reality: nature at the millennium*. Eds. Braun, B. & Castree, N. Routledge: London & New York. pp. 3-42.

Catley, A., Alders, R.G. & Wood, J.L.N. (2012) Participatory epidemiology: approaches, methods, experiences. *The Veterinary Journal*, 191, 151-160.

Chalmers, J.C. (1976) – PRONI AG/33/30. Public Record Office for Northern Ireland File AG/33/30: Tuberculosis Policy, Part 1, 1972-1977. Memorandum dated 2 March 1976.

Cheshire, L., Meurk, C. & Woods, M. (2013) Decoupling farm, farming and place: recombinant attachments of globally engaged family farmers. *Journal of Rural Studies*, 30, 64-74.

Christiansen, E.A.N. (2013) Negative externalities of food production: discourses on the contested Norwegian aquaculture industry. *Journal of Political Ecology*, 20, 180-198.

Christley, R.M. Mort, M., Wynne, B., Wastling, J.M., Heathwaite, A.L., Pickup, R., Austin, Z. & Latham, S.M. (2013) "Wrong, but useful": negotiating uncertainty in infectious disease modelling. *PLoS ONE*, 8 (10): e76277. doi:10.1371/journal.pone.0076277.

Claridge, J., Diggle, P., McCann, C.M., Mulcahy, G., Flynn, R., McNair, J., Strain, S., Welsh, M., Baylis, M. & Williams, D.J.L. (2012) *Fasciola hepatica* is associated with the failure to detect bovine tuberculosis in dairy cattle. *Nature Communications,* 3, 853, doi:10.1038/ncomms1840.

Clark, N. (2007) Animal interface: the generosity of domestication. In: *Where the wild things are now: domestication reconsidered*. Eds. Cassidy, R. & Mullin, M. Berg: Oxford & New York. pp. 49 – 70.

Clark, N. (2011) *Inhuman nature: sociable life on a dynamic planet*. Sage: London, Thousand Oaks, CA, New Delhi, Singapore.

Clark, N. (2013) Mobile life: biosecurity practices and insect globalization. *Science as Culture,* 22, 16-37.

Cloke, P. (1994) (En)culturing political economy: a life in the day of a 'rural geographer'. In: *Writing the rural: five cultural geographies*. Cloke, P., Doel, M., Matless, D., Phillips, M. & Thrift, N. Paul Chapman Publishing Ltd: London. pp. 149-190.

Cloke, P. (1997) Country backwater to virtual village? Rural studies and the 'cultural turn.' *Journal of Rural Studies*, 13, 367-375.

Cloke, P. (2013) Rural landscapes. In: *The Wiley-Blackwell companion to cultural geography*. Eds. Johnson, N.C., Schein, R.H. & Winders, J. Wiley-Blackwell: Chichester. pp. 225-237.

Closser, S. (2012) 'We can't give up now': global health optimism and polio eradication in Pakistan. *Medical Anthropology*, 31, 385-403.

Collard, R-C. (2012) Cougar-human entanglements and the biopolitical un/making of safe space. *Environment and Planning D: Society and Space*, 30, 23-42.

Collins, J.D. (2006) Tuberculosis in cattle: strategic planning for the future. *Veterinary Microbiology*, 112, 369-381.

Collins, C.H. & Grange, J.M. (1983) A review: the bovine tubercle bacillus. *Journal of Applied Bacteriology*, 55, 13-29.

Collins, D. & Kearns, R. (2007) Ambiguous landscapes: sun, risk and recreation on New Zealand beaches. In: *Therapeutic landscapes*. Ed. Williams, A. Ashgate: Aldershot. pp. 15-32.

Conlan, A.J.K., McKinley, T.J., Karolemeas, K., Brooks-Pollock, E., Goodchild, A.V., Mitchell, A.P., Birch, C.P.D., Clifton-Hadley, R.S. & Wood, J.L.N. (2012) Estimating the hidden burden of bovine tuberculosis in Great Britain. *PLOS Computational Biology*, 8, e1002730. doi: 10.1371/journal.pcbi.1002730.

Connolly, J.H. (1968) Q fever in Northern Ireland. *British Medical Journal*, 1, 547-552.

Corner, L.A.L., Murphy, D. & Gormley, E. (2011) *Mycobacterium bovis* infection in the Eurasian badger (*Meles meles*): the disease, pathogenesis, epidemiology and control. *Journal of Comparative Pathology*, 144, 1-24.

Cosma, C.L., Humbert, O., Sherman, D.R. & Ramakrishnan, L. (2008) Trafficking of superinfecting *Mycobacterium* organisms into established granulomas occurs in mammals and is independent of the Erp and ESX-1 mycobacterial virulence loci. *The Journal of Infectious Diseases,* 198, 1851-1855.

Cowie, C.E., Beck, B.B., Gortazar, C., Vicente, J., Hutchings, M.R., Moran, D. & White, P.C.L. (2014) Risk factors for the detected presence of *Mycobacterium bovis* in cattle in south central Spain. *European Journal of Wildlife Research*, 60, 113-123.

Cox, G., Lowe, P. & Winter, M. (1986) The state and the farmer: perspectives on agricultural policy. In: *Agriculture: people and policies*. Allen & Unwin: Hemel Hempstead, Winchester, MA, North Sydney. pp. 1-19.

Craddock, S. (1995) Sewers and scapegoats: spatial metaphors of smallpox in nineteenth century San Francisco. *Social Science & Medicine*, 41, 957-968.

Crang, M. (2001) Filed work: making sense of group interviews. In: *Qualitative methodologies for geographers: issues and debates*. Eds. Limb, M. & Dwyer, C. Arnold: London. pp. 215-233.

Crang, M. (2003) Telling materials. In: *Using social theory: thinking through research*. Eds. Pryke, M., Rose, G. & Whatmore, S. SAGE Publications Ltd.: London, Thousand Oaks & New Delhi. pp. 127-144.

Crang, M. (2004) Fields. In: *Patterned ground: entanglements of nature and culture*. Eds. Harrison, S., Pile, S. & Thrift, N. Reaktion Books: London. pp. 88-90.

Crang, M. & Cook, I. (2007) *Doing ethnographies*. Sage: London, Thousand Oaks, CA, New Delhi, Singapore.

Cresswell, T. (2014) Mobilities III: moving on. *Progress in Human Geography*, published early view online at doi: 10.1177/0309132514530316.

Crews, K.A. & King, B. (2013) Human health at the nexus of ecologies and politics. In: Eds. King. B. & Crews, K.A. *Ecologies and politics of health*. Routledge: Abingdon & New York. pp. 1-12.

Crossley, N. (1993) The politics of the gaze: between Foucault and Merleau-Ponty. *Human Studies*, 16, 399-419.

Crowhurst, I. (2013) The fallacy of the instrumental gate? Contextualising the process of gaining access through gatekeepers. *International Journal of Social Research Methodology,* 16, 463-475.

Crowhurst, I. & Kennedy-Macfoy, M. (2013) Troubling gatekeepers: methodological considerations for social research. *International Journal of Social Research Methodology*, 16, 457-462.

Dairy Council NI (2013) Facts about Northern Ireland's dairy industry. Available online at: http://www.dairycouncil.co.uk/consumers/industry/northern-irelands-dairy-industry. Accessed 22 October 2013.

DARD (n.d.) Wild deer TB surveillance 2008/09. Available online at: http://www.dardni.gov.uk/print/index/animal-health-and-welfare/animal-diseases/bovine-tuberculosis/tb-research-and-development/wild-deer-tb-surveillance-2008-09.htm. Accessed 27 January 2014.

DARD (2004) Biosecurity code for Northern Ireland farms. Department of Agriculture & Rural Development: Belfast.

DARD (2013a) The agricultural census in Northern Ireland: results for June 2013. Department of Agriculture & Rural Development: Belfast.

DARD (2013b) Statistical review of Northern Ireland agriculture 2012. Department of Agriculture & Rural Development: Belfast.

DARD (2013c) New partnership to work to eradicate TB – O'Neill. Northern Ireland Executive, September 2013 news releases. Available at: http://www.northernireland.gov.uk/index/media-centre/news-departments/news-dard/news-dard-170913-new-partnership-to.htm. Accessed 25 February 2014.

DARD (2014a) Statistical review of Northern Ireland agriculture 2013. Department of Agriculture & Rural Development: Belfast.

DARD (2014b) Tuberculosis disease statistics in Northern Ireland. Available online at: http://www.dardni.gov.uk/index/statistics/animal-disease-statistics/statistics-tuberculosis.htm. Accessed 3 May 2014.

David, E. (1984) Economic differences between agriculture and industry. In: *Paths of development in capitalist agriculture: readings from German social democracy, 1891-99*. Eds. Hussain, A. & Tribe, K. Trans. by Fowkes, B. The Macmillan Press Ltd: London & Basingstoke.

Davies, G. & Burgess, J. (2004) Challenging the 'view from nowhere': citizen reflections on specialist expertise in a deliberative process. *Health & Place*, 10, 349-361.

Davis, D.K. (2001) Veterinary geography as interdisciplinary research. *The Geographical Review*, 91, 463-471.

Davis, D.K. (2007) *Resurrecting the granary of Rome: environmental history and French colonial expansion in North Africa*. Ohio University Press: Athens, OH.

Davis, D.K. (2009) Historical political ecology: on the importance of looking back to move forward. *Geoforum*, 40, 285-286.

Dawson, A. (1997) Identity and strategy in post-productivist agriculture: a case study from Northern Ireland. In: *Culture and policy in Northern Ireland: anthropology in the public arena*. Eds. Donnan, H. & McFarlane, G. The Institute of Irish Studies, The Queen's University of Belfast: Belfast. pp. 37-58.

Dean, G.S., Rhodes, S.G., Coad, M., Whelan, A.O., Cockle, P.J., Clifford, D.J., Hewinson, R.G. & Vordermeier, H.M. (2005) Minimum infective dose of *Mycobacterium bovis* in cattle. *Infection and Immunity,* 73, 6467-6471.

De Certeau, M. (1984) *The practice of everyday life*. University of California Press: Berkeley, Los Angeles & London.

DEFRA (2014) The strategy for achieving Officially Bovine Tuberculosis Free status for England. Available online at: https://www.gov.uk/government/publications/a-strategy-for-achieving-officially-bovine-tuberculosis-free-status-for-england. Accessed 15 May 2014.

De Kantor, I.N. & Roswurm, J.D. (1978) Mycobacteria isolated from nasal secretions of tuberculin test reactor cattle. *American Journal of Veterinary Research,* 39, 1233-1234.

De la Rua-Domenech, R. (2006) Human *Mycobacterium bovis* infection in the United Kingdom: incidence, risks, control measures and review of the zoonotic aspects of bovine tuberculosis. *Tuberculosis*, 86, 77-109.

De la Rua-Domenech, R., Goodchild, A.T., Vordermeier, H.M., Hewinson, R.G., Christiansen, K.H. & Clifton-Hadley, R.S. (2006) Ante mortem diagnosis of tuberculosis in cattle: a review of the tuberculin tests, γ-interferon assay and other ancillary diagnostic techniques. *Research in Veterinary Science*, 81, 190-210.

Deleuze, G. & Guattari, F. (1987) *A thousand plateaus: capitalism and schizophrenia*. Trans. by Massumi, B. University of Minnesota Press: Minneapolis & London.

Deleuze, G. & Parnet, C. (2006) *Dialogues II*. Trans. by Tomlinson, H. & Habberjam, B. Continuum: London & New York.

DeLyser, D. & Sui, D. (2014) Crossing the qualitative-quantitative chasm III: enduring methods, open geography, participatory research, and the fourth paradigm. *Progress in Human Geography*, 38, 294-307.

Department of Agriculture, Food and the Marine (2014) TB statistics in Republic of Ireland. Available online at: http://www.agriculture.gov.ie/animalhealthwelfare/diseasecontrol/bovinetbbrucellosiseradicationschemes/statistics/tbstats/. Accessed 14 April 2014.

Devaney, L. (2013) Spaces of security, surveillance and food safety: interrogating perceptions of the Food Safety Authority of Ireland's governing technologies, power and performance. *The Geographical Journal*, 179, 320-330.

Dexter, L.A. (2006) *Elite and specialized interviewing*. ECPR Press: Colchester.

Doolittle, A.A. (2010) Stories and maps, images and archives: multimethod approach to the political ecology of native property rights and natural resource management in Sabah, Malaysia. *Environmental Management*, 45, 67-81.

Donaldson, A. & Wood, D. (2004) Surveilling strange materialities: categorization in the evolving geographies of FMD biosecurity. *Environment and Planning D: Society and Space*, 22, 373-391.

Donaldson, A., Ward, N. & Bradley, S. (2010) Mess among disciplines: interdisciplinarity in environmental research. *Environment and Planning A*, 42, 1521-1536.

Dörries, M. (2001) Purity and objectivity in nineteenth-century metrology and literature. *Perspectives on Science*, 9, 233-250.

Douglas, M. (1966) *Purity and danger: an analysis of concepts of pollution and taboo*. Routledge & Kegan Paul: London & Henley.

Douglas, M. (2003) *Risk acceptability according to the social sciences. Mary Douglas Collected Works Vol. XI*. Routledge: London & New York.

Dowling, R. (2010) Power, subjectivity, and ethics in qualitative research. In: *Qualitative research methods in human geography*. Ed. Hay, I. Oxford University Press: Ontario. pp. 26-39.

Dove, M.R. (1983) Theories of swidden agriculture, and the political economy of ignorance. *Agroforestry Systems*, 1, 85-99.

Drewe, J.A., O'Connor, H.M., Weber, N., McDonald, R.A. & Delahay, R.J. (2013) Patterns of direct and indirect contact between cattle and badgers naturally infected with tuberculosis. *Epidemiology & Infection*, 141, 1467-1475.

Dry, S. & Leach, M. (2010a) *Epidemics: science, governance and social justice*. Earthscan: London & Washington, DC.

Dry, S. & Leach, M. (2010b) Towards conclusions: science, politics and social justice in epidemic accounts and responses. In: *Epidemics: science, governance and social justice*. Eds. Dry, S. & Leach, M. Earthscan: London & Washington, DC. pp. 239-256.

Dunnet, G.M., Jones, D.M. & McInerney, J.P. (1986) *Badgers and bovine tuberculosis*. HMSO: London.

DuPuis, E.M. & Block, D. (2008) Sustainability and scale: US milk-market orders as relocalization policy. *Environment and Planning A*, 40, 1987-2005.

Dwyer, S.C. & Buckle, J.L. (2009) The space between: on being an insider-outsider in qualitative research. *International Journal of Qualitative Methods*, 8, 54-63.

Dyck, N. (2000) Home field advantage? Exploring the social construction of children's sports. In: *Constructing the field: ethnographic fieldwork in the contemporary world*. Ed. Amit, V. Routledge: London & New York. pp. 32-53.

EC (2002) Consolidated version of the treaty establishing the European Community. *Official Journal of the European Communities*. C 325/33.

EC (2003) Council Regulation (EC) No 1782/2003 of 29 September 2003 establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers and amending Regulations (EEC) No 2019/93, (EC) No 1452/2001, (EC) No 1453/2001, (EC) No 1454/2001, (EC) 1868/94, (EC) No 1251/1999, (EC) No 1254/1999, (EC) No 1673/2000, (EEC) No 2358/71 and (EC) No 2529/2001. *Official Journal of the European Communities*, 270, 21.10.2003.

Edwards, C.J.W. (1991) Spatial changes in livestock production in Northern Ireland: 1974-1986. *Journal of Rural Studies*, 7, 277-283.

EEC (1964) Council Directive of 26 June 1964 on animal health problems affecting intra-Community trade in bovine animals and swine (64/432/EEC). *Official Journal of the European Communities*, Series 1 Chapter 1963-1964, 164-184.

EEC (1977) Council Directive of 17 May 1977 introducing community measures for the eradication of brucellosis, tuberculosis and leucosis in cattle (as amended) (77/391/EEC). *Official Journal of the European Communities*, No L145, 44-47.

EFSA/ECDC (2014) The European Union summary report on trends and sources of zoonoses, zoonotic agents and foodborne outbreaks in 2012. *EFSA Journal*, 12, 3547. Available online at:
http://www.efsa.europa.eu/en/efsajournal/doc/3547.pdf. Accessed 2 March 2014.

Elden, S. (2004) *Understanding Henri Lefebvre: theory and the possible*. Continuum: London & New York.

Elder-Vass, D. (2008) Searching for realism, structure and agency in Actor Network Theory. *The British Journal of Sociology*, 59, 455-473.

Elder-Vass, D. (2014) Disassembling actor-network theory. *Philosophy of the Social Sciences,* published early online at doi: 10.1177/0048393114525858.

Ellis, J.C. (1996) On the search for a root cause; essentialist tendencies in environmental discourse. In: *Uncommon ground: rethinking the human place in nature*. Ed. Cronon, W. W.W. Norton & Co: New York & London. pp. 256-268.

Ellis-Iversen, J., Cook, A.J.C., Watson, E., Nielen, M., Larkin, L., Wooldridge, M. & Hogeveen, H. (2010) Perceptions, circumstances and motivators that influence implementation of zoonotic control programs on cattle farms. *Preventive Veterinary Medicine,* 93, 276-285.

Elwood, S. & Martin, D.G. (2000) 'Placing' interviews: location and scales of power in qualitative research. *Professional Geographer*, 52, 649-657.

Emel, J. & Neo, H. (2011) Killing for profit: global livestock industries and their socio-ecological implications. In: *Global Political Ecology*. Eds. Peet, R., Robbins, P. & Watts, M. Routledge: Abingdon & New York pp. 67-83.

Emery, S.B., Perks, M.T. & Bracken, L.J. (2013) Negotiating river restoration: the role of divergent reframing in environmental decision-making. *Geoforum*, 47, 167-177.

Engel-Di Mauro, S. (2009) Seeing the local in the global: political ecologies, world-systems, and the question of scale. *Geoforum*, 40, 116-125.

England, K. V. L. (1994) Getting personal: reflexivity, positionality, and feminist research. *The Professional Geographer*, 46, 80-89.

Enticott, G. (2001) Calculating nature: the case of badgers, bovine tuberculosis and cattle. *Journal of Rural Studies,* 17, 149–164.

Enticott, G. (2003) Lay immunology, local foods and rural identity: defending unpasteurized milk in England. *Sociologia Ruralis*, 43, 257-270.

Enticott, G. (2008a) The ecological paradox: social and natural consequences of the geographies of animal health promotion. *Transactions of the Institute of British Geographers,* 33, 433-446.

Enticott, G. (2008b) The spaces of the biosecurity: prescribing and negotiating solutions to bovine tuberculosis. *Environment and Planning A,* 40, 1568–1582.

Enticott, G. (2011) Techniques of neutralising wildlife crime in rural England and Wales. *Journal of Rural Studies,* 27, 200–208.

Enticott, G. (2012a) The local universality of veterinary expertise and the geography of animal disease. *Transactions of the Institute of British Geographers*, 37, 75-88.

Enticott, G. (2012b) Regulating animal health, gender and quality control: a study of veterinary surgeons in Great Britain. *Journal of Rural Studies*, 28, 559-567.

Enticott, G. (2014) Relational distance, neoliberalism and the regulation of animal health. *Geoforum*, 52, 42-50.

Enticott, G. & Franklin, A. (2009) Biosecurity, expertise and the institutional void: the case of bovine tuberculosis. *Sociologia Ruralis,* 49, 375-393.

Enticott, G. & Vanclay, F. (2011) Scripts, animal health and bisosecurity: the moral accountability of farmers' talk about animal health risks. *Health, Risk and Society*, 13, 293-309.

Enticott, G., Donaldson, A., Lowe, P., Power, M., Proctor, A. & Wilkinson, K. (2011) The changing role of veterinary expertise in the food chain. *Philosophical Transactions of the Royal Society B*, 366, 1955-1965.

Enticott, G., Franklin, A. & Van Winden, S. (2012a) Biosecurity and food security: spatial strategies for combating bovine tuberculosis in the UK. *The Geographical Journal*, 178, 327-337.

Enticott, G., Maye, D., Ilbery, B., Fisher, R. & Kirwan, J. (2012b) Farmers' confidence in vaccinating badgers against bovine tuberculosis. *Veterinary Record*, 170, 204.

Etherington, T.R., Trewby, I.D., Wilson, G.J. & McDonald, R.A. (2014) Expert opinion-based relative landscape isolation maps for badgers across England and Wales. *Area*, 46, 50-58.

European Commission (2004) Final report of a mission carried out in the United Kingdom from 17 to 26 November 2004 in order to evaluate the bovine tuberculosis eradication programme. European Commission Health & Consumer Protection Directorate-General, Directorate F – Food and Veterinary Office. DG(SANCO)/7251/2004 – MR Final. European Commission: Brussels.

European Commission (2013) CAP expenditure in the total EU expenditure (2007 constant prices). Available online at: http://ec.europa.eu/agriculture/cap-post-2013/graphs/graph1_en.pdf. Accessed 19 October 2013.

Evans, N., Morris, C. & Winter, M. (2002) Conceptualising agriculture: a critique of post-productivism as the new orthodoxy. *Progress in Human Geography*, 26, 313-332.

Evans, T.G., Brennan, M.J., Barker, L. & Thole, J. (2013) Preventive vaccines for tuberculosis. *Vaccine*, 31S, B223-B226.

Fairhead, J. & Leach, M. (1996) *Misreading the African landscape: society and ecology in a forest-savanna mosaic*. Cambridge University Press: Cambridge, New York & Melbourne.

Fairhead, J. & Leach, M. (1998) *Reframing deforestation: global analysis and local realities: studies in West Africa*. Routledge: London & New York.

Fairhead, J. & Leach. M. (2003) *Science, society and power: environmental knowledge and policy in West Africa and the Caribbean*. Cambridge University Press: Cambridge.

Farmer, J., Munoz, S-A. & Daly, C. (2012) Being rural in rural health research. *Health & Place*, 18, 1206-1208.

Federle, M.J. & Bassler, B.L. (2003) Interspecies communication in bacteria. *The Journal of Clinical Investigation,* 112, 1291-1299.

Finch, J. (1984) 'It's great to have someone to talk to': the ethics and politics of interviewing women. In: *Social researching: politics, problems, practice*. Eds. Bell, C. & Roberts, H. Routledge & Kegan Paul: London, Boston, Melbourne & Henley. pp. 70-87.

Fine, B. (2005) From Actor-Network Theory to political economy. *Capitalism Nature Socialism*, 16, 91-108.

Fine, A.E., Bolin, C.A., Gardiner, J.C. & Kaneene, J.B. (2011) A study of the persistence of *Mycobacterium bovis* in the environment under natural weather conditions in Michigan, USA. *Veterinary Medicine International*, 2011, 1-12.

Fish, R., Austin, Z., Christley, R., Haygarth, P.M., Heathwaite, L.A., Latham. S., Medd, W., Mort, M., Oliver, D.M., Pickup, R., Wastling, J.M. & Wynne, B. (2011) Uncertainties in the governance of animal disease: an interdisciplinary framework for analysis. *Philosophical Transactions of the Royal Society B*, 366, 2023-2034.

Fisher, R. (2013) 'A gentleman's handshake': the role of social capital and trust in transforming information into usable knowledge. *Journal of Rural Studies*, 31, 13-22.

Fisher, R., Maye, D., Ilbery, B., Enticott, G. & Kirwan, J. (2012) The spatial distribution of bovine tuberculosis in England. *Geography,* 97, 68-77.

Flynn R.J., Mulcahy G., Welsh, M., Cassidy, J.P., Corbett, D., Milligan, C., Andersen, P., Strain, S. & McNair, J. (2009) Co-infection of cattle with *Fasciola hepatica* and *Mycobacterium bovis* – immunological consequences. *Transboundary and Emerging Diseases,* 56, 269-274.

Fonterra (2013) The New Zealand dairy industry. Available online at: http://www.fonterra.com/global/en/Financial/Global+Dairy+Industry/New+Zealand+Dairy+Industry. Accessed 22 October 2013.

Forman, R.T.T. (1995) *Land mosaics: the ecology of landscapes and regions*. Cambridge University Press: Cambridge.

Forsyth, T. (1998) Mountain myths revisited: integrating natural and social environmental science. *Mountain Research and Development*, 18, 107-116.

Forsyth, T. (2003) *Critical political ecology: the politics of environmental science*. Routledge: London & New York.

Forsyth, T. (2011) Politicizing environmental explanations: what can political ecology learn from sociology and philosophy of science? In: *Knowing nature: conversations at the intersection of political ecology and science studies*. Eds. Goldman, M.J., Nadasdy, P. & Turner, M.D. University of Chicago Press: Chicago & London. pp. 31-46.

Foucault, M. (1977) *Discipline and punish*. Trans. by Sheridan, A. Vintage Books: New York.

Foucault, M. (1997) *The birth of the clinic: an archaeology of medical perception*. Trans. by Sheridan, A. Routledge: London.

Frankena, K., White, P.W., O'Keeffe, J., Costello, E., S. W. Martin, S.W., Grevenhof, I.V. & More, S.J. (2007) Quantification of the relative efficiency of factory surveillance in the disclosure of tuberculosis lesions in attested Irish cattle. *Veterinary Record*, 161, 679-684.

Fujimura, J. (2011) Technobiological imaginaries: how do systems biologists know nature? In: *Knowing nature: conversations at the intersection of political ecology and science studies*. Eds. Goldman, M.J., Nadasdy, P. & Turner, M.D. University of Chicago Press: Chicago & London. pp. 65-80.

Galt, R.E. (2010) Scaling up political ecology: the case of illegal pesticides on fresh vegetables imported into the United States, 1996-2006. *Annals of the Association of American Geographers*, 100, 327-355.

Galt, R.E. (2013a) Placing food systems in first world political ecology: a review and research agenda. *Geography Compass*, 7, 637-658.

Galt, R.E. (2013b) The moral economy is a double-edged sword: explaining farmers' earnings and self-exploitation in community-supported agriculture. *Economic Geography*, 89, 341-365.

Galt, R.E. (2013c) From *Homo economicus* to complex subjectivities: reconceptualising farmers as pesticide users. *Antipode*, 45, 336-356.

Gannon, B.W., Hayes, C.M. & Roe, J.M. (2007) Survival rate of airborne *Mycobacterium bovis*. *Research in Veterinary Science*, 82, 169-172.

Gareau, B.J. (2005) We have never been human: agential nature, ANT, and Marxist political ecology. *Capitalism Nature Socialism,* 16, 127-140.

Gasson, R. (1973) Goals and values of farmers. *Journal of Agricultural Economics*, 24, 521-542.

Gates, M.C., Volkova, V.V. & Woolhouse, M.E.J. (2013) Risk factors for bovine tuberculosis in low incidence regions related to the movements of cattle. *BMC Veterinary Research,* 9, 225.

Gesler, W.M. (1992) Therapeutic landscapes: medical issues in light of the new cultural geography. *Social Science & Medicine*, 34, 735-746.

Gezon, L.L. (2006) *Global visions, local landscapes: a political ecology of conservation, conflict, and control in Northern Madagascar*. Altamira Press, Rowman & Littlefield Publishers Inc.: Lanham, New York, Toronto & Plymouth.

Gilbert, M.R. (1994) The politics of location: doing feminist research at 'home'. *Professional Geographer*, 46, 90-96.

Ginn, F. (2013) Sticky lives: slugs, detachment and more-than-human ethics in the garden. *Transactions of the Institute of British Geographers*, published early view online at doi: 10.1111/tran.12043.

Glaser, B.G. & Strauss, A.L. (2008) *The discovery of grounded theory: strategies for qualitative research.* Aldine Transaction: New Brunswick & London.

Glover, R.E. (1937) A short survey of Sir John McFadyean's contributions to the study of tuberculosis. *Journal of Comparative Pathology and Therapeutics*, 50, 356-376.

Godfray, H.C.J., Donnelly, C.A., Kao, R.R., Macdonald, D.W., McDonald, R.A., Petrokofsky, G., Wood, J.L.N., Woodroffe, R., Young, D.B. & McLean, A.R. (2013) A restatement of the natural science evidence base relevant to the control of bovine tuberculosis in Great Britain. *Proceedings of the Royal Society B*, 280, 20131634.

Goldman, M. (2007) Tracking wildebeest, locating knowledge: Maasai and conservation biology understandings of wildebeest behaviour in Northern Tanzania. *Environment and Planning D: Society and Space*, 25, 307-331.

Goldman, M.J. (2011) The politics of connectivity across human-occupied landscapes: corridors near Nairobi National Park, Kenya. In: *Knowing nature: conversations at the intersection of political ecology and science studies*. Eds. Goldman, M.J., Nadasdy, P. & Turner, M.D. University of Chicago Press: Chicago & London. pp. 186-202.

Goldman, M. & Schurman, R.A. (2000) Closing the "great divide": new social theory on society and nature. *Annual Review of Sociology*, 26, 563-584.

Goldman, M.J. & Turner, M.D. (2011) Introduction. In: *Knowing nature: conversations at the intersection of political ecology and science studies*. Eds. Goldman, M.J., Nadasdy, P. & Turner, M.D. University of Chicago Press: Chicago & London. pp. 1-23.

Goldman, M.J., Nadasdy, P. & Turner, M.D. (2011) *Knowing nature: conversations at the intersection of political ecology and science studies*. University of Chicago Press: Chicago & London.

Gormley, E. & Corner, L.A.L. (2013) Control strategies for wildlife tuberculosis in Ireland. *Transboundary and Emerging Diseases*, 60, 128-135.

Gormley, E., Doyle, M., Duignan, A., Good, M., More, S.J. & Clegg, T. A. (2013) Identification of risk factors associated with disclosure of false positive bovine tuberculosis reactors using the gamma-interferon (IFNγ) assay. *Veterinary Research*, 44, 117.

Goss, J.D. (1996) Introduction to focus groups. *Area*, 28, 113-114.

Goss, J.D. & Leinbach, T.R. (1996) Focus groups as alternative research practice: experience with transmigrants in Indonesia. *Area*, 28, 115-123.

Grant, W. (1997) *The Common Agricultural Policy*. Palgrave: Basingstoke & New York.

Grant, W. (2009) Intractable policy failure: the case of bovine TB and badgers. *The British Journal of Politics and International Relations,* 11, 557-573.

Grant, W. (2012) Can political science contribute to agricultural policy? *Policy and Society*, 31, 271-279.

Gray, J. (1999) Open spaces and dwelling places: being at home on hill farms in the Scottish Borders. *American Ethnologist*, 26, 440-460.

Green, D.M., Kiss, I.Z., Mitchell, A.P. & Kao, R.P. (2008) Estimates for local and movement-based transmission of bovine tuberculosis in British cattle. *Proceedings of the Royal Society B*, 275, 1001-1005.

Greenberg, J.B. (2006) The political ecology of fisheries in the Upper Gulf of California. In: *Reimagining political ecology*. Eds. Biersack, A. & Greenberg, J.B. Duke University Press: Durham & London. pp. 121-148.

Greenhough, B. (2012) Where species meet and mingle: endemic human-virus relations, embodied communication and more-than-human agency at the Common Cold Unit 1946-90. *Cultural Geographies,* 19, 281-301.

Greenwood, B. (2009) Can malaria be eliminated? *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 103S, S2-S5.

Gregson, N. (2011) Performativity, corporeality and the politics of ship disposal. *Journal of Cultural Economy*, 4, 137-156.

Gregson, N. (2012) Projected futures: the political matter of UK higher activity radioactive waste. *Environment and Planning A,* 44, 2006-2022.

Gregson, N., Watkins, H. & Calestani, M. (2010) Inextinguishable fibres: demolition and the vital materialisms of asbestos. *Environment and Planning A,* 42, 1065-1083.

Griffiths, H., Poulter, I. & Sibley, D. (2000) Feral cats in the city. In: *Animal spaces, beastly places: new geographies of human-animal relations*. Eds. Philo, C. & Wilbert, C. Routledge: London & New York. pp. 56-70.

Gummesson, E. (1991) *Qualitative methods in management research*. SAGE Publications: Newbury Park, London & New Delhi.

Gupta, A.C. (2013) Elephants, safety nets and agrarian culture: understanding human-wildlife conflict and rural livelihoods around Chobe National park, Botswana. *Journal of Political Ecology*, 20, 238-254.

Guthman, J. (2004) *Agrarian dreams: the paradox of organic farming in California*. University of California Press: Berkeley, Los Angeles & London.

Hajer, M.A. (1995) *The politics of environmental discourse: ecological modernization and the policy process*. Oxford University Press: Oxford & New York.

Hajer, M.A. (2009) *Authoritative governance: policy-making in the age of mediatization*. Oxford University Press: Oxford.

Hall, D. (2010) Food with a visible face: traceability and the public promotion of private governance in the Japanese food system. *Geoforum*, 41, 826-835.

Hall, J. & Pretty, J. (2008) Then and now: Norfolk farmers' changing relationships and linkages with government agencies during transformations in land management. *Journal of Farm Management*, 13, 393-418.

Hamilton, L. (2007) Muck and magic: cultural transformations in the world of farm animal veterinary surgeons. *Ethnography*, 8, 485-501.

Hamilton, L. (2012) Purity in danger: power, negotiation and ontology in medical practice. *International Journal of Organizational Analysis*, 20, 95-106.

Hamlin, C. (2009) *Cholera: the biography*. Oxford University Press: Oxford.

Haraway, D. (1988) Situated knowledges: the science question in feminism and the privilege of partial perspective. *Feminist Studies*, 14, 575-599.

Haraway, D.J. (2003) *The companion species manifesto: dogs, people, and significant otherness*. Prickly Paradigm Press: Chicago.

Harman, G. (2002) *Tool-Being: Heidegger and the metaphysics of objects*. Open Court: Chicago & La Salle, IL.

Harman, G. (2011) *The quadruple object*. Zero Books: Winchester & Washington.

Harris, C. (2001) Archival fieldwork. *The Geographical Review*, 91, 328-334.

Harvey, D. (1996) *Justice, nature and the geography of difference*. Blackwell Publishers: Cambridge, MA & Oxford.

Harvey, D. & Hubbard. C. (2013) Reconsidering the political economy of farm animal welfare: an anatomy of market failure. *Food Policy*, 38, 105-114.

Heaney, S. (1980) 'Digging'. In: *Seamus Heaney: selected poems 1965-1975*. Faber and Faber: London & Boston. pp. 10-11.

Heidegger, M. (1962) *Being and time*. Trans. by Macquarrie, J. & Robinson, E. Basil Blackwell Ltd: Oxford.

Heidegger, M. (1977a) *The question concerning technology and other essays*. Harper & Row: New York, Hagerstown, San Francisco & London.

Heidegger, M. (1977b) The question concerning technology. In: *Martin Heidegger: basic writings*. Ed. Krell, D.F. HarperCollins: New York. pp. 311-341.

Heidegger, M. (1995) *The fundamental concepts of metaphysics: world, finitude, solitude*. Trans. by McNeill, W. & Walker, N. Indiana University Press: Bloomington & Indianapolis.

Herbert, S. (2000) For ethnography. *Progress in Human Geography*, 24, 550-568.

Herod, A. (1999) Reflections on interviewing foreign elites: praxis, positionality, validity, and the cult of the insider. *Geoforum*, 30, 313-327.

Hinchliffe, S. (2001) Indeterminacy in-decisions – science, policy and politics in the BSE (Bovine Spongiform Encephalopathy) crisis. *Transactions of the Institute of British Geographers*, 26, 182-204.

Hinchliffe, S. (2007) *Geographies of nature: societies, environments, ecologies*. Sage Publications Ltd.: London, Thousand Oaks, New Delhi & Singapore.

Hinchliffe, S. & Whatmore, S. (2006) Living cities: towards a politics of conviviality. *Science as Culture,* 15, 123-138.

Hinchliffe, S. & Bingham, N. (2008) Securing life: the emerging practices of biosecurity. *Environment and Planning A*, 40, 1534-1551.

Hinchliffe, S., Allen, J., Lavau, S., Bingham, N. & Carter, S. (2013) Biosecurity and the topologies of infected life: from borderlines to borderlands. *Transactions of the Institute of British Geographers*, 38, 531-543.

Hird, M.J. (2009) *The origins of sociable life: evolution after science studies.* Palgrave Macmillan: Basingstoke & New York.

Hodgetts, T. & Lorimer, J. (2014) Methodologies for animals' geographies: cultures, communication and genomics. *Cultural Geographies*, published early online at doi: 10.1177/1474474014525114.

Hoggart, K., Lees, L. & Davies, A. (2002) *Researching human geography*. Arnold: London.

Holloway, L. (2004) Showing and telling farming: agricultural shows and re-imaging British agriculture. *Journal of Rural Studies*, 20, 319-330.

Holloway, L. (2007) Subjecting cows to robots: farming technologies and the making of animal subjects. *Environment and Planning D: Society and Space,* 25, 1041-1060.

Holloway, L., Morris, C., Gilna, B. & Gibbs, D. (2009) Biopower, genetics and livestock breeding: (re)constituting animal populations and heterogeneous biosocial collectivities. *Transactions of the Institute of British Geographers,* 34, 394-407.

Holloway, L., Bear, C. & Wilkinson, K. (2014) Re-capturing bovine life: robot-cow relationships, freedom and control in dairy farming. *Journal of Rural Studies*, 33, 131-140.

Homer (1946) *The Odyssey*. Trans. by Rieu, E.V. Penguin Books: London.

Hopkins, P. (2007a) Thinking critically and creatively about focus groups. *Area*, 39, 528-535.

Hopkins, P. (2007b) Positionalities and knowledge: negotiating ethics in practice. *ACME: An International E-Journal for Critical Geographie*s, 6, 386-394.

House of Commons (2013) Vaccination against bovine TB. Environment, Food and Rural Affairs Committee, Second Report of Session 2013-14. Volume 1: Report, together with formal minutes, oral and written evidence. Published 5 June 2013. The Stationery Office Limited: London.

Howley, P., Breen, J., Donoghue, C.O. & Hennessy, T. (2012) Does the single farm payment affect farmers' behaviour? A macro and micro analysis. *International Journal of Agricultural Management*, 2, 57-64.

Howley, P., Dillon, E. & Hennessy, T. (2014) It's not all about the money: understanding farmers' labor allocation choices. *Agriculture and Human Values*, 31, 261-271.

Hughes, E.C. (1971) *The sociological eye: selected papers*. Aldine Atherton Inc: Chicago & New York.

Ilbery, B.W. (1978) Agricultural decision-making: a behavioural perspective. *Progress in Human Geography*, 2, 448-466.

Ilbery, B. (2012) Interrogating food security and infectious animal and plant diseases: a critical introduction. *The Geographical Journal*, 178, 308-312.

Ingram, M. (2007) Disciplining microbes in the implementation of US federal organic standards. *Environment and Planning A*, 39, 2866-2882.

Ingram, J. (2008) Agronomist-farmer knowledge encounters: an analysis of knowledge exchange in the context of best management practices in England. *Agriculture and Human Values*, 25, 405-418.

Jansen, K. (2009) Implicit sociology, interdisciplinarity and systems theories in agricultural science. *Sociologia Ruralis*, 49, 172-188.

Jansen, J., Van Den Borne, B.H.P., Renes, R.J., Van Schaik, G., Lam, T.J.G.M. & Lewis, C. (2009) Explaining mastitis incidence in Dutch dairy farming: the influence of farmers' attitudes and behaviour. *Preventive Veterinary Medicine,* 92, 210-223.

Jasanoff, S. (1987) Contested boundaries in policy-relevant science. *Social Studies of Science*, 17, 195-230.

Jasanoff, S. (2004) *States of knowledge: the co-production of science and social order*. Routledge: Abingdon & New York.

Jay, M. (2007) The political economy of a productivist agriculture: New Zealand dairy discourses. *Food Policy*, 32, 266-279.

Jokinen, P. (2002) The European Union as a suprastate in agri-environmental issues: the Finnish perspective. *The environmental state under pressure*, Vol 10. Elsevier Science: Oxford. pp. 105-120.

Jones, G. (2001) *Captain of all these men of death – the history of tuberculosis in nineteenth and twentieth century Ireland*. Editions Rodopi B.V.: Amsterdam & New York.

Jones, S. (2008) Political ecology and land degradation: how does the land lie 21 years after Blaikie and Brookfield's *Land Degradation and Society*? *Geography Compass*, 2, 671-694.

Jones, O. (2013) "Who milks the cows at Maesgwyn?" The animality of UK rural landscapes in affective registers. *Landscape Research*, 38, 421-442.

Jones, B. & Ficklin, L. (2012) To walk in their shoes: recognising the expression of empathy as a research reality. *Emotion, Space and Society*, 5, 103-112.

Juntti, M. (2012) Implementing cross compliance for agriculture in the EU: relational agency, power and action in different socio-material contexts. *Sociologia Ruralis*, 52, 294-310.

Kao, R.R. (2013) Bovine tuberculosis – a workshop with views from around the world. Available online at: http://boydorrblog.wordpress.com/category/bovine-tuberculosis/ Accessed 23 October 2013.

Kao, R.R., Gravenor, M.B., Charleston, B., Hope, J.C., Martin, M. & Howard, C.J. (2007) *Mycobacterium bovis* shedding patterns from experimentally infected calves and the effect of concurrent infection with bovine diarrhoea virus. *Journal of the Royal Society Interface,* 4, 545-551.

Kerr, W.R., Lamont, H.G. & McGirr, J.L. (1946) Studies on tuberculin sensitivity in the bovine. *Veterinary Record*, 58, 443-446.

Kerr, W.R., Lamont, H.G. & McGirr, J.L. (1949) Further studies on tuberculin sensitivity in the bovine. *Veterinary Record*, 16, 466.

King, L.S. (1952) Is medicine an exact science? *Philosophy of Science*, 19, 131-140.

King. B. (2010) Political ecologies of health. *Progress in Human Geography*, 34, 38-55.

King. B. & Crews, K.A. (2013) *Ecologies and politics of health*. Routledge: Abingdon & New York.

Kirke, A.W. (1989) The influence of milk supply quotas on dairy farm performance in Northern Ireland. In: *Milk quotas in the European Community*. Ed. Burrell, A. Oxford: CAB International. pp. 30-45.

Kitzinger, J. (1994) The methodology of focus groups: the importance of interaction between research participants. *Sociology of Health & Illness*, 16, 103-121.

Klepac, P., Metcalf, C. J. E., Mclean, A.R. & Hampson, K. (2013) Towards the endgame and beyond: complexities and challenges for the elimination of infectious diseases. *Philosophical Transactions of the Royal Society B*, 368: 20120137.

Knigge, L. & Cope, M. (2006) Grounded visualization: integrating the analysis of qualitative and quantitative data through grounded theory and visualization. *Environment and Planning A*, 38, 2021-2037.

Knight, J. (2000) Introduction. In: *Natural enemies: people-wildlife conflicts in anthropological perspective*. Ed. Knight, J. Routledge: London & New York. pp. 1-35.

Kosek, J. (2010) Ecologies of empire: on the new uses of the honeybee. *Cultural Anthropology*, 25, 650-678.

Koutalakis, C., Buzogany, A. & Börzel, T.A. (2010) When soft regulation is not enough: the integrated pollution prevention and control directive of the European Union. *Regulation & Governance*, 4, 329-344.

Krebs, J.R., Anderson, R., Clutton-Brock, T., Morrison, I., Young, D. & Donnelly, C. (1997) *Bovine tuberculosis in cattle and badgers*. MAFF: London.

Lambin, E.F., Tran, A., Vanwambeke, S.O., Linard, C. & Soti, V. (2010) Pathogenic landscapes: interactions between land, people, disease vectors, and their animal hosts. *International Journal of Health Geographics*, 9, 54.

Lane, S.N., Odoni, N., Landström, C., Whatmore, S.J., Ward, N. & Bradley, S. (2011) Doing flood risk science differently: an experiment in radical scientific method. *Transactions of the Institute of British Geographers*, 36, 15-36.

Latour, B. (1987) *Science in action: how to follow scientists and engineers through society*. Harvard University Press: Cambridge, MA.

Latour, B. (1988) *The pasteurization of France*. Trans. by Sheridan, A. and Law, J. Harvard University Press: Cambridge, MA & London.

Latour, B. (1993) *We have never been modern*. Harvester Wheatsheaf: Hemel Hempstead.

Latour, B. (1996) *ARAMIS or the love of technology*. Trans. by Porter, C. Harvard University Press: Cambridge, MA & London.

Latour, B. (2000) When things strike back: a possible contribution of 'science studies' to the social sciences. *British Journal of Sociology*, 51, 107-123.

Latour, B. (2004) Why has critique run out of steam? From matters of fact to matters of concern. *Critical Inquiry*, 30, 225-248.

Latour, B. & Woolgar, S. (1979) *Laboratory life: the social construction of scientific facts*. SAGE Publications: Beverly Hills & London.

Lavau, S. (2014) Viruses: from travel companion to companion species. In: *The Routledge handbook of mobilities*. Eds. Adey, P., Bissell, D., Hannam, K., Merriman, P. & Sheller, M. Routledge: Abingdon & New York. pp. 298-305.

Lave, R. (2011) Circulating knowledge, constructing expertise. In: *Knowing nature: conversations at the intersection of political ecology and science studies*. Eds. Goldman, M.J., Nadasdy, P. & Turner, M.D. University of Chicago Press: Chicago & London. pp. 263-279.

Lave, R. (2012) Bridging political ecology and STS: a field analysis of the Rosgen Wars. *Annals of the Association of American Geographers*, 102, 366-382.

Law, J. (1986) On the methods of long-distance control: vessels, navigation and the Portuguese route to India. In: *Power, action and belief: a new sociology of knowledge?* Ed. Law. J. Routledge & Kegan Paul: London, Boston & Henley. pp. 234-263.

Law, J. (1987) Technology and heterogeneous engineering: the case of Portuguese expansion. In: *The social construction of technological systems: new directions in the sociology and history of technology*. Eds. Bijker, W.E., Hughes, T.P. & Pinch, T.J. The MIT Press: Cambridge, MA & London. pp. 111-134.

Law, J. (2002) *Aircraft stories: decentering the object in technoscience*. Duke University Press: Durham, NC & London.

Law, J. (2003) Making a mess with method. Centre for Science Studies, Lancaster University: Lancaster. Available online at: http://www.lancaster.ac.uk/sociology/research/publications/papers/law-making-a-mess-with-method.pdf. Accessed 31 March 2014.

Law, J. (2004) *After method: mess in social science research*. Routledge: Abingdon.

Law, J. (2006) Disaster in agriculture: or foot and mouth mobilities. *Environment and Planning A,* 38, 227-239.

Law, J. (2008a) On sociology and STS. *The Sociological Review*, 56, 623-649.

Law, J. (2008b) Culling, catastrophe and collectivity. *Distinktion: Scandinavian Journal of Social Theory*, 16, 61-76.

Law, J. (2009) Collateral realities. Version of 29th December 2009, available online at: http://www.heterogeneities.net/publications/Law2009CollateralRealities.pdf. Accessed 29 November, 2013.

Law, J. (2010a) Care and killing: tensions in veterinary practice. In: *Care in practice*. Eds. Mol, A., Moser, I. & Pols, J. Transaction Publishers: Bielefeld. pp. 57-71.

Law, J. (2010b) The materials of STS. In: *The Oxford handbook of material studies*. Eds. Hicks, D. & Beaudry, M.C. Oxford University Press: Oxford. pp. 173-188.

Law, J. & Lodge, P. (1984) *Science for social scientists*. The Macmillan Press Ltd: London & Basingstoke.

Law, J. & Singleton, V. (2005) Object lessons. *Organization*, 12, 331-355.

Law, J. & Mol, A. (2008a) Globalisation in practice: on the politics of boiling pigswill. *Geoforum*, 39, 133-143.

Law, J. & Mol, A. (2008b) The actor-enacted: Cumbrian sheep in 2001. In: *Material agency*: *towards a non-anthropocentric approach*. Eds. Knappett, C. & Malafouris, L. Springer: Dusseldorf. pp. 57-77.

Law, J. & Mol. A. (2011) Veterinary realities: what is Foot and Mouth Disease? *Sociologia Ruralis*, 51, 1-16.

Law, J. & Moser, I. (2012) Contexts and culling. *Science, Technology, & Human Values*, 37, 332-354.

Law, J. & Lien, M. (2013) Slippery: field notes in empirical ontology. *Social Studies of Science*, 43, 363-378.

Law, J. & Ruppert, E. (2013) Introduction. The social life of methods: devices. *Journal of Cultural Economy*, 6, 229-240.

Lawhon, M., Ernstson, H. & Silver, J. (2014) Provincializing urban political ecology: towards a situated UPE through African urbanism. *Antipode*, 46, 497-516.

Leach, M. & Mearns, R. (1996) *The lie of the land: challenging received wisdom on the African environment*. The International African Institute in association with James Currey Ltd & Heinemann: London, Oxford & Portsmouth, NH.

Leach, M. & Fairhead, J. (2007) *Vaccine anxieties: global science, child health and society*. Earthscan: London & Sterling, VA.

Leach, M. & Dry, S. (2010) Epidemic narratives. In: *Epidemics: science, governance and social justice.* Eds. Dry, S. & Leach, M. Earthscan: London & Washington, DC. pp. 1-21.

Leach, M. & Scoones, I. (2013) The social and political lives of zoonotic disease models: narratives, science and policy. *Social Science & Medicine*, 88, 10-17.

Leach, M. & Tadros, M. (2014) Epidemics and the politics of knowledge: contested narratives in Egypt's H1N1 response. *Medical Anthropology*, 33, 240-254.

Leach, M., Sumner, A. & Waldman, L. (2008) Discourses, dynamics and disquiet: multiple knowledges in science, society and development. *Journal of International Development*, 20, 727-738.

Leach, M., Scoones, I. & Stirling, A. (2010) Governing epidemics in an age of complexity: narratives, politics and pathways to sustainability. *Global Environmental Change*, 20, 369-377.

Lee, R.M. & Renzetti, C.M. (1993) The problems of researching sensitive topics: an overview and introduction. In: *Researching sensitive topics*. Eds., Lee, R.M. & Renzetti, C.M. Sage Publications: Newbury Park, London & New Delhi.

Lehane, R. (1996) *Beating the odds in a big country: the eradication of bovine brucellosis and tuberculosis in Australia*. CSIRO Publishing: Collingwood, Victoria.

Li, T.M. (2005) Beyond "the State" and failed schemes. *American Anthropologist*, 107, 383-394.

Li, T.M. (2007) Practices of assemblage and community forest management. *Economy and Society*, 36, 263-293.

Lin, P.L. & Flynn, J.L. (2010) Understanding latent tuberculosis: a moving target. *Journal of Immunology*, 185, 15-22.

Lipsky, M. (1980) *Street-level bureaucracy: dilemmas of the individual in public services*. Russell Sage Foundation: New York.

Livingstone, D. N. (1992a) *The geographical tradition*. Blackwell Publishers: Oxford & Cambridge, MA.

Livingstone, D. N. (1992b) In defence of situated messiness: geographical knowledge and the history of science. *GeoJournal*, 26, 22-229.

Lofland, J. & Lofland, L.H. (1995) *Analyzing social settings: a guide to qualitative observation and analysis*. Third edition. Wadsworth: Belmont, CA.

Longhurst, R. (2001) *Bodies: exploring fluid boundaries*. Routledge: London & New York.

Lorimer, H. (2010) Caught in the nick of time: archives and fieldwork. In: *The SAGE handbook of qualitative geography*. Eds. DeLyser, D., Herbert, S., Aitken, S., Crang, M. & McDowell, L. SAGE: Los Angeles, London, New Delhi, Singapore & Washington DC. pp. 248-273.

Lorimer, J. (2012) Multinatural geographies for the Anthropocene. *Progress in Human Geography*, 36, 593-612.

Lowe, P. & Ward, N. (1997) Field-level bureaucrats and the making of new moral discourses in agri-environmental controversies. In: *Globalising food: agrarian questions and global restructuring*. Eds. Goodman, D. & Watts, M.J. Routledge: London & New York. pp. 256-272.

Lowe, P., Murdoch, J., Marsden, T., Munton, R. & Flynn, A. (1993) Regulating the new rural spaces: the uneven development of land. *Journal of Rural Studies*, 9, 205-222.

Lowe, P. Clark, J., Seymour, S. & Ward, N. (1997) *Moralizing the environment: countryside change, farming and pollution*. UCL Press: London & Bristol, PA.

Luckey, D.F. (1917) The intradermal test. In: *Bovine Tuberculosis*. Ed. DeVine, J.F. American Veterinary Publishing Co.: Chicago. pp. 79-100.

Macnaghten, P. & Urry, J. (1998) *Contested natures*. Sage Publications: London, Thousand Oaks & New Delhi.

Macnaghten, P. & Myers, G. (2007) Focus groups. In: *Qualitative research practice*. Eds. Seale, C., Gobo, G., Gubrium, J.F. & Silverman, D. SAGE Publications: Los Angeles, London, New Delhi & Singapore. pp. 65-79.

Macnaghten, P. & Chilvers, J. (2014) The future of science governance: publics, policies, practices. *Environment and Planning C: Government and Policy*, 32, 530-548.

Magnusson, H. (1941) The relation between bovine and human tuberculosis from the veterinary point of view. *Acta Medica Scandinavica*, Supplementum CXXXV, 201-239.

Mallard, A. (1998) Compare, standardize and settle agreement: on some usual metrological problems. *Social Studies of Science*, 28, 571-601.

MANI (1951) Ministry of Agriculture for Northern Ireland Monthly Reports, Volume 25, January 1951, 270-272.

MANI (1959a) Ministry of Agriculture for Northern Ireland Monthly Reports, Volume 34, May 1959, 13-15.

MANI (1959b) Ministry of Agriculture for Northern Ireland Monthly Reports, Volume 34, October 1959, 183-184.

MANI (1960a) Ministry of Agriculture for Northern Ireland Monthly Reports, Volume 34, January 1960, 273-274.

MANI (1960b) Ministry of Agriculture for Northern Ireland Monthly Reports, Volume 34, March 1960, 369-370.

Mansfield, B. (2007) Articulation between neoliberal and state-oriented environmental regulation: fisheries privatization and endangered species protection. *Environment and Planning A*, 39, 1926- 1942.

Mansfield, L. (2012) Hill farming identities and connections to place. In: *Making sense of place: multidisciplinary perspectives*. Eds. Convery, I., Corsane, G. & Davis, P. The Boydell Press: Woodbridge. pp. 67-78.

Manson, P. (1998) Letter 02/005 to Ronald Ross, dated 28th June 1895. In: *The beast in the mosquito: the correspondence of Ronald Ross and Patrick Manson*. Bynum, W.F. & Overy, C. Rodopi B.V.: Amsterdam & Atlanta.

Marsden, T. (1988) Exploring political economy approaches in agriculture. *Area*, 20, 315-322.

Marsden, T. (2013) From post-productionism to reflexive governance: contested transitions in securing more sustainable food futures. *Journal of Rural Studies*, 29, 123-134.

Marsden, T., Munton, R., Ward, N. & Whatmore, S. (1996) Agricultural geography and the political economy approach: a review. *Economic Geography*, 72, 361-375.

Martin, R. (2001) Geography and public policy: the case of the missing agenda. *Progress in Human Geography*, 25, 189-210.

Marx, K. (1976) *Capital*. Volume 1. Trans. by Fowkes, B. Penguin Books: Harmondsworth.

Mather, C. & Marshall, A. (2011) Living with disease? Biosecurity and avian influenza in ostriches. *Agriculture & Human Values*, 28, 153-165.

Maurice, J. (2014) Polio eradication effort sees progress, but problems remain. *The Lancet*, 383, 939-940.

Mayer, J.D. (1996) The political ecology of disease as one new focus for medical geography. *Progress in Human Geography*, 20, 441-456.

Mayer, J.D. (2000) Geography, ecology and emerging infectious diseases. *Social Science and Medicine*, 50, 937-952.

McCallan, L., McNair, J. & Skuce, R. (2014) A review of the potential role of cattle slurry in the spread of bovine tuberculosis. Agri-Food and Biosciences Institute: Belfast. Available online at: http://www.dardni.gov.uk/tb-slurry-lit-review.pdf. Accessed 5 May 2014.

McCarthy, J. (2002) First World political ecology: lessons from the Wise Use movement. *Environment and Planning A*, 34, 1281-1302.

McFarlane, C. (2011) Assemblage and critical urban praxis: part one. *City*, 15, 204-224.

McGuirk, P. (2011) Policy research as critical praxis. *Dialogues in Human Geography*, 1, 233-237.

Menzies, F.D. & Neill, S.D. (2000) Cattle-to-cattle transmission of bovine tuberculosis. *The Veterinary Journal,* 160, 92-106.

Menzies, F.D., Abernethy, D.A., Stringer, L.A. & Jordan, C. (2011) A comparison of badger activity in two areas of high and low bovine tuberculosis incidence of Northern Ireland. *Veterinary Microbiology*, 151, 112-119.

Messer, J. (1987) The sociology and politics of land degradation in Australia. In: *Land degradation and society*. Eds. Blaikie, P. & Brookfield, H. Methuen: London & New York. pp. 232-238.

Moda, G. (2006) Non-technical constraints to eradication: the Italian experience. *Veterinary Microbiology*, 112, 253-258.

Mohammad, R. (2001) 'Insiders' and/or 'outsiders': positionality, theory and praxis. In: *Qualitative methodologies for geographers: issues and debates*. Eds. Limb, M. & Dwyer, C. Oxford University Press: London & New York. pp. 101-117.

Mol, A. (1998) Lived reality and the multiplicity of norms: a critical tribute to George Canguilhem. *Economy and Society*, 27, 274-284.

Mol, A. (2002) *The body multiple: ontology in medical practice*. Duke University Press: Durham & London.

Mol, A. & Law, J. (1994) Regions, networks and fluids: anaemia and social topology. *Social Studies of Science*, 24, 641-671.

Mol, A. & Law, J. (2002) Complexities: an introduction. In: *Complexities: social studies of knowledge practices*. Eds. Law, J. & Mol, A. Duke University Press: Durham, NC & London. pp. 1-22.

Monaghan, M. L., Doherty, M.L., Collins, J.D., Kazda, J.F. & Quinn, P.J. (1994) The tuberculin test. *Veterinary Microbiology*, 40, 111-124.

Monies, R.J. (2000) Tuberculous pneumonia and BVD in housed calves. *Cattle Practice,* 8, 119-125.

Moore, V.A. (1905) *Bovine tuberculosis: the most important contagious disease of cattle*. Bulletin C – No. 1. Montana State Veterinary Department: Helena, MT.

Moore, V.A. (1913) *Bovine tuberculosis and its control*. Carpenter & Co.: Ithaca, NY.

Moore, D.S. (1996) Marxism, culture, and political ecology: environmental struggles in Zimbabwe's Eastern Highlands. In: *Liberation ecologies: environment, development, social movements*. Eds. Peet, R. & Watts, M. Routledge: London & New York. pp. 125-147.

Moore, L.J. & Kosut, M. (2013) Among the colony: ethnographic fieldwork, urban bees and intra-species mindfulness. *Ethnography*, published early online at doi: 10.1177/1466138113505022.

More, S. J. (2007) What is needed to eradicate bovine TB successfully: an Irish perspective? *The Veterinary Journal*, 180, 275-278.

Morris, C. (2006a) Negotiating the boundary between state-led and farmer approaches to knowing nature: an analysis of UK agri-environment schemes. *Geoforum*, 37, 113-127.

Morris, C. (2006b) Public policy, (agri)environment and rural geography: critical reflections on two decades of research in the UK. Published in Spanish as: Política pública, (agro) ambiente y geografía rural: reflexiones críticas sobre dos décadas de investigación en Gran Bretaña. *Boletin de la Asociacion de Geografos Espanoles*, 41, 15-38.

Morris, C. & Evans, N. (1999) Research on the geography of agricultural change: redundant or revitalized? *Area*, 31, 349-358.

Morris, J.M. & McBeth, M.K. (2003) The New West in the context of extractive commodity theory: the case of bison-brucellosis in Yellowstone National Park. *The Social Science Journal*, 40, 233-247.

Morris, C. & Evans, N. (2004) Agricultural turns, geographical turns: retrospect and prospect. *Journal of Rural Studies*, 20, 95-111.

Morris, C. & Holloway, L. (2009) Genetic technologies and the transformation of the geographies of UK livestock agriculture: a research agenda. *Progress in Human Geography,* 33, 313-333.

Mort, M. (2002) *Building the Trident network: a study of the enrolment of people, knowledge, and machines*. The MIT Press: Cambridge, MA & London.

Moser, S. (2008) Personality: a new positionality? *Area*, 40, 383-392.

Moss, J. (1986) Small scale farming in the Northern Ireland economy. In: *Agriculture: people and policies*. Eds. Cox, G., Lowe, P. & Winter, M. Allen & Unwin: London. pp. 93-104.

Muldavin, J. (2008) The time and place for political ecology: an introduction to the articles honouring the life-work of Piers Blaikie. *Geoforum*, 39, 687-697.

Mulligan, K., Elliott, S.J. & Schuster-Wallace, C. (2012) The place of health and the health of place: Dengue fever and urban governance in Putrajaya, Malaysia. *Health & Place*, 18, 613-620.

Murdoch, J. (1997) Inhuman/nonhuman/human: actor–network theory and the prospects for a non-dualistic and symmetrical perspective on nature and society. *Environment and Planning D: Society and Space*, 15, 731–756.

Murdoch, J. & Pratt, A.C. (1993) Rural studies: modernism, postmodernism and the 'post-rural'. *Journal of Rural Studies*, 9, 411-427.

Murdoch, J. & Ward, N. (1997) Governmentality and territoriality: the statistical manufacture of Britain's 'national farm'. *Political Geography*, 16, 307-324.

Myers, G. & Macnaghten, P. (1998) Rhetorics of environmental sustainability: commonplaces and places. *Environment and Planning A,* 30, 333-353.

Nally, D. (2014) Governing precarious lives: land grabs, geopolitics, and 'food security'. *The Geographical Journal*, published early online at doi: 10.1111/geoj.12063.

Napier, A.D. (2012) Nonself help: how immunology might reframe the enlightenment. *Cultural Anthropology,* 27, 122-137.

Neill, S.D., Hanna, J., O'Brien, J.J. & McCracken, R.M. (1989) Transmission of tuberculosis from experimentally infected cattle to in-contact calves. *Veterinary Record*, 124, 269-271.

Neill, S.D, O'Brien, J.J. & Hanna, J. (1991) A mathematical model for *Mycobacterium bovis* excretion from tuberculous cattle. *Veterinary Microbiology,* 28, 103-109.

Neumann, R.P. (1992) Political ecology of wildlife conservation in the Mt. Meru area of Northeast Tanzania. *Land Degradation and Rehabilitation*, 3, 85-98.

Neumann, R.P. (2005) *Making political ecology*. Hodder Arnold: London.

Neumann, R.P. (2008) Probing the (in)compatibilities of social theory and policy relevance in Piers Blaikie's political ecology. *Geoforum*, 39, 728-735.

NIAO (1993) *Department of Agriculture: animal health measures. Report by the Comptroller and Auditor General for Northern Ireland*. Northern Ireland Audit Office, 27 May 1993. HMSO: London.

NIAO (2009) *The control of bovine tuberculosis in Northern Ireland. Report by the Comptroller and Auditor General*. Northern Ireland Audit Office. NIA 92/08-09, 18 March 2009. The Stationery Office: Belfast.

NI Assembly (2012a) Review into bovine tuberculosis, Volume 1, together with the minutes of proceedings of the committee relating to the summary, the minutes of evidence and correspondence. Agriculture and Rural Development Committee. NIA 83/11-15, 13 November 2012.

NI Assembly (2012b) Northern Ireland Assembly. Bovine TB Review: Ministerial Briefing, 3 July 2012, Official Report (Hansard). Committee for Agriculture and Rural Development. Available online at: http://www.niassembly.gov.uk/Documents/Official-Reports/Agriculture/2011-2012/Bovine%20TB%20Review%20Ministerial%20Briefing.pdf. Accessed 16 May 2014.

NI Assembly (2013a) Northern Ireland Assembly. Common Agricultural Policy, Rural Development Programme, Tuberculosis and Agrifood: Ministerial Briefing, 17 September 2013. Committee for Agriculture and Rural Development. Official Report (Hansard). Available online at: http://www.niassembly.gov.uk/Documents/Official-Reports/Agriculture/2013-2014/130917_CAPRDPTBagrifood(Ministerialbriefing).pdf. Accessed 16 May 2014.

NI Assembly (2013b). Badger sett survey/test, vaccinate or remove exercise: DARD update. Committee for Agriculture and Rural Development. Official Report (Hansard), Session 2012/13, Tuesday 25 June 2013. Available at: http://www.niassembly.gov.uk/Assembly-Business/Official-Report/Committee-Minutes-of-Evidence/Session-2012-2013/June-2013/Badger-Sett-SurveyTest-Vaccinate-or-Remove-Exercise--DARD-Update/ Accessed 18 February 2014.

Northern Ireland Executive (2013a) Programme for government 2011-2015. Available online at: http://www.northernireland.gov.uk/pfg-2011-2015-final-report.pdf Accessed 23 October 2013.

Northern Ireland Executive (2013b) Economic strategy**:** priorities for sustainable growth and prosperity. Available online at: http://www.northernireland.gov.uk/ni-economic-strategy-revised-130312.pdf Accessed 23 October 2013.

Noy, C. (2008) Sampling knowledge: the hermeneutics of snowball sampling in qualitative research. *International Journal of Social Research Methodology*, 11, 327-344.

O'Connor, R. (1986) *A study of the bovine tuberculosis eradication scheme*. Paper 133. The Economic and Social Research Institute: Dublin.

O'Connor, J. (1993) Is sustainable capitalism possible? In: *Food for the future: conditions and contradictions of sustainability*. Ed. Allen, P. John Wiley & Sons Inc: New York. pp. 125-137.

Offen, K.H. (2004) Historical political ecology: an introduction. *Historical Geography*, 32, 19-42.

Ogden, L. (2011). *Swamplife: people, gators, and mangroves entangled in the Everglades*. University of Minnesota Press: Minneapolis.

O'Hagan, M.J.H., Matthews, D.I., Laird, C. & McDowell, S.W.J. (2013) Bovine tuberculosis biosecurity study: County Down, Northern Ireland 2010-2011. Agri-Food and Biosciences Institute: Belfast. Available online at: http://www.dardni.gov.uk/tb-biosecurity-study.pdf. Accessed 22 January 2014.

OIE (2013) *Terrestrial animal health code*. World Animal Health Organisation: Paris. Available online at: http://www.oie.int/en/international-standard-setting/terrestrial-code/access-online/ Accessed 1 March 2014.

Olmstead, A.L. & Rhode, P.W. (2004) An impossible undertaking: the eradication of bovine tuberculosis in the United States. *The Journal of Economic History*, 64, 734-772.

Olmstead, A.L. & Rhode, P.W. (2007) Not on my farm! Resistance to bovine tuberculosis eradication in the United States. *The Journal of Economic History*, 67, 768-809.

O'Meara, D.B., Edwards, C.J., Sleeman, D. P., Cross, T.F., Statham, M.J., McDowell, J.R., Dillane, E., Coughlan, J.P., O'Leary, D., O'Reilly, C., Bradley, D.G. & Carlsson, J. (2012) Genetic structure of Eurasian badgers *Meles meles* (Carnivora: Mustelidae) and the colonization history of Ireland. *Biological Journal of the Linnean Society*, 106, 893–909.

O'Neill, S. & Nicholson-Cole, S. (2009) "Fear won't do it" Promoting positive engagement with climate change through visual and iconic representations. *Science Communication*, 30, 355-379.

Oullier, O. (2013) Behavioural insights are vital to policy-making. *Nature*, 501, 463.

Oxford Economics (2012) *Regional price disparities in deadweight cattle: understanding the NI/GB price differential. Final Report*. December 2013. Available online at: http://www.lmcni.com/fs/doc/publications/regional-price-disparities-in-deadweight-cattle.pdf. Accessed 28 February 2014.

PAC (2009) Northern Ireland Assembly Public Accounts Committee report on the control of bovine tuberculosis in Northern Ireland, together with the minutes of proceedings of the committee relating to the report and the minutes of evidence. Report 40/08/09R. NI Assembly: Belfast.

Pain, R., Kesby, M. & Askins, K. (2011) Geographies of impact: power, participation and potential. *Area*, 43, 183-188.

Palmer, S., Fozdar, F. & Sully, M. (2009) The effect of trust on West Australian farmers' responses to infectious livestock diseases. *Sociologia Ruralis*, 49, 360-374.

Paxson, H. (2008) Post-Pasteurian cultures: the microbiopolitics of raw-milk cheese in the United States. *Cultural Anthropology,* 23, 15-47.

Payne, A., Boschiroli, M.L., Gueneau, E., Moyen, J.L., Rambaud, T., Dufour, B., Gilot-Fromont, E. & Hars, J. (2013) Bovine tuberculosis in "Eurasian" badgers (*Meles meles*) in France. *European Journal of Wildlife Research*, 59, 331-339.

Peck, J. (1999) Editorial: grey geography? *Transactions of the Institute of British Geographers*, 24, 131-135.

Peet, R. & Watts, M. (1993) Introduction: development theory and environment in an age of market triumphalism. *Economic Geography*, 69, 227-253.

Peet, R. & Watts, M. (1996) *Liberation ecologies: environment, development, social movements*. Routledge: London & New York.

Peet, R. & Watts, M. (2004) *Liberation ecologies: environment, development, social movements*. Second edition. Routledge: London & New York.

Peet, R., Robbins, P. & Watts, M. (2011) *Global political ecology*. Routledge: Abingdon & New York.

Peloquin, C. (2013) Locust swarms and the spatial techno-politics of the French Resistance in World War II. *Geoforum*, 49, 103-113.

Perkins, H.A. (2007) Ecologies of actor-networks and (non)social labor within the urban political economies of nature. *Geoforum*, 38, 1152-1162.

Petersen, B. & Stuart, D. (2014) Explanations of a changing landscape: a critical examination of the British Columbia bark beetle epidemic. *Environment and Planning A*, 46, 598-613.

Pfeiffer, D.U. (2013) Epidemiology caught in the causal web of bovine tuberculosis. *Transboundary and Emerging Diseases*, 60, 104-110.

Pile, S. (1990) *The private farmer: transformation and legitimation in advanced capitalist agriculture*. Dartmouth Publishing Co. Ltd: Aldershot.

Pinch, T. (1993) "Testing – one, two, three ... testing!": toward a sociology of testing. *Science, Technology, & Human Values*, 18, 25-41.

Pini, B. (2002) Focus groups, feminist research and farm women: opportunities for empowerment in rural social research. *Journal of Rural Studies*, 18, 339-351.

Pini, B. (2004) On being a nice country girl and an academic feminist: using reflexivity in rural social research. *Journal of Rural Studies*, 20, 169-179.

Pollock, J.M. & Neill, S.D. (2002) *Mycobacterium bovis* infection and tuberculosis in cattle *Veterinary Journal*, 163, 115-127.

Poltorak, M., Leach, M., Fairhead, J. & Cassell, J. (2005) 'MMR talk' and vaccination choices: an ethnographic study in Brighton. *Social Science & Medicine*, 61, 709-719.

Pool, W.A. (1945) The eradication of tuberculosis in cattle. Disease in relation to animal husbandry. *Proceedings of the Royal Society of Medicine*, 39, 77-82.

Porter, T. (1995) *Trust in numbers: the pursuit of objectivity in science and public life.* Princeton University Press: Princeton, NJ.

Porter, J.D.H. (2006) Epidemiological reflections of the contribution of anthropology to public health policy and practice. *Journal of Biosocial Science*, 38, 133-144.

Pratt, A.C. (1995) Putting critical realism to work: the practical implications for geographical research. *Progress in Human Geography*, 19, 61-74.

Pratt, A.C. (2013) '… the point is to change it': critical realism and human geography. *Dialogues in Human Geography*, 3, 26-29.

Pritchard, D.G. (1988) A century of bovine tuberculosis 1888-1988: conquest and controversy. *Journal of Comparative Pathology,* 99, 357-399.

Proctor, A., Donaldson, A., Phillipson, J. & Lowe, P. (2012) Field expertise in rural land management. *Environment and Planning A*, 44, 1696-1711.

PRONI AG/33/30 (1972-1977) Public Record Office of Northern Ireland file. Tuberculosis Policy, Part 1, 1972-1977.

PRONI AG/33/30-a (1972) Memorandum from Chief Veterinary Officer to Dr Jack – 30 March 1972.

PRONI AG/33/30-b (1975) Memorandum from Mr R.N. Martin – June 1975.

PRONI AG/33/30-c (1975) Memorandum from Mr J.S. Ogg – 18 August 1975.

PRONI AG/33/30-d (1975) Memorandum from Mr H.L. Hutchinson - 26 September 1975.

PRONI AG/33/30-e (1975) Memorandum from Mr T.E. Christie - 22 September 1975.

PRONI AG/33/30-f (1975) Letter to A.J. Green (Dept. of Finance) from J.C. Chalmers on frequency of testing - 12 December 1975.

PRONI AG/33/30-g (1976) Bovine tuberculosis eradication: note of a meeting in room 712 on March 10 1976 to discuss the review of tuberculosis policy.

PRONI AG/33/30-h (1976) Memorandum from Mr J.C. Chalmers to CVO - 7 April 1976.

PRONI AG/33/30-i (1976) Bovine tuberculosis eradication: note of a meeting in room 712 on 5 May 1976 to discuss the review of tuberculosis policy.

PRONI AG/33/30-j (1976) Memorandum from Mr J.C. Chalmers to CVO in response to the meeting to discuss the review of tuberculosis policy on 5 May 1976 – 19 May 1976.

PRONI AG/33/30-k (1976) Bovine tuberculosis eradication, note of a meeting held in room 712 on Thursday 21 October 1976 at 10.30am.

PRONI AG/33/30-l (1977) Bovine tuberculosis eradication quarterly review, notes of a meeting held in room 719 on Tuesday 26 April 1977 at 1030.

PRONI AG/33/30-m (1977) Minutes of meeting on 18 November 1977 at 1000 hours in CVO's room, tuberculosis review and accelerated programmes.

Prudham, W.S. (2005) *Knock on wood*. Routledge: New York & Abingdon.

Public Health England (2013) Case notification numbers of *Mycobacterium bovis* from humans by country, UK 1999-2012. Available online at: http://www.hpa.org.uk/Topics/InfectiousDiseases/InfectionsAZ/Tuberculosis/TBUKSurveillanceData/EnhancedMycobacteriumBovisSurveillance/TBMbovis01countryregion/. Accessed 22 November 2013.

Radunz, B. (2006) Surveillance and risk management during the latter stages of eradication: experiences from Australia. *Veterinary Microbiology*, 112, 283-290.

Ramisch, J.J. (2011) Experiments as “performances”: interpreting farmers’ soil fertility management practices in western Kenya. In: *Knowing nature: conversations at the intersection of political ecology and science studies*. Eds. Goldman, M.J., Nadasdy, P. & Turner, M.D. University of Chicago Press: Chicago & London. pp. 280-295.

Reid, N., Etherington, T.R., Wilson, G.J., Montgomery, I. & McDonald, R.A. (2011) Monitoring and population estimation of the European badger *Meles meles* in Northern Ireland. *Wildlife Biology*, 18, 46-57.

Reid, N., Wilson, G.J., Montgomery, W.I. & McDonald, R.A. (2012) Changes in the prevalence of badger persecution in Northern Ireland. *European Journal of Wildlife Research*, 58, 177-183.

Reilly, L.V. (1950) Human tuberculosis of bovine origin in Northern Ireland. *The Journal of Hygiene*, 48, 464-471.

Riley, M. (2008) Experts in their fields: farmer-expert knowledges and environmentally friendly farming practices. *Environment and Planning A*, 40, 1277-1293.

Riley, M (2009a) ‘The next link in the chain’: children, agri-cultural practices and the family farm. *Children's Geographies*, 7, 245-260.

Riley, M. (2009b) Bringing the ‘invisible farmer’ into sharper focus: gender relations and agricultural practices in the Peak District (UK). *Gender, Place and Culture*, 16, 665-682.

Riley, M. (2010) Emplacing the research encounter: exploring farm life histories. *Qualitative Inquiry*, 16, 651-662.

Riley, M (2011a) 'Letting them go': agricultural retirement and human-livestock relations. *Geoforum*, 42, 16-27.

Riley, M. (2011b) Turning farmers into conservationists? Progress and prospects. *Geography Compass*, 5, 369-389.

Riley, M. (2012) 'Moving on'? Exploring the geographies of retirement adjustment amongst farming couples. *Social and Cultural Geography*, 13, 759-781.

Riley, M. & Harvey, D. (2007) Oral histories, farm practice and uncovering meaning in the countryside. *Social & Cultural Geography*, 8, 391-415.

Rinaldi, A. (2012) Yaws eradication: facing old problems, raising new hopes. *PLoS Neglected Tropical Diseases*, 6, e1837.

Ritchie, J.N. (1959) *Britain's achievement in the eradication of bovine tuberculosis*. The George Scott Robertson Memorial Lecture. Delivered in the Sir William Whitla Hall, The Queen's University of Belfast on 31 October, 1958. Marjory Boyd: Belfast.

Robbins, P. (1998) Paper forests: imagining and deploying exogenous ecologies in arid India. *Geoforum*, 29, 69-86.

Robbins, P. (2000) The practical politics of knowing: state environmental knowledge and local political economy. *Economic Geography*, 76, 126-144.

Robbins, P. (2002). Letter to the editor: obstacles to a First World political ecology? Looking near without looking up. *Environment and Planning A*, *34*, 1509-1513.

Robbins, P. (2003) Beyond ground truth: GIS and the environmental knowledge of herders, professional foresters, and other traditional communities. *Human Ecology*, 31, 233-253.

Robbins, P. (2004) *Political ecology*. Blackwell Publishing: Malden, Oxford, Carlton.

Robbins, P. (2006) The politics of barstool biology: Environmental knowledge and power in greater Northern Yellowstone. *Geoforum*, 37, 185-199.

Robbins, P. (2007) *Lawn people: how grasses, weeds, and chemicals make us who we are*. Temple University Press: Philadelphia.

Robbins, P. (2008) The state in political ecology: a postcard to political geography from the field. In: *The SAGE handbook of political geography*. Eds. Cox, K.R., Low, M. & Robinson, J. SAGE Publications: Los Angeles, London, New Delhi & Singapore. pp. 205-218.

Robbins, P. (2012a) *Political ecology*. Second edition. Wiley-Blackwell: Malden, Oxford, Chichester.

Robbins, P. (2012b) A review of *Knowing nature: conversations at the intersection of political ecology and science studies*. Eds. Goldman, M.J., Nadasdy, P. & Turner, M.D. University of Chicago Press: Chicago & London. *Annals of the Association of American Geographers*, 102, 883-885.

Robbins, P. (2013) Choosing metaphors for the anthropocene. In: *The Wiley-Blackwell companion to cultural geography*. Eds. Johnson, N.C., Schein, R.H. & Winders, J. Wiley-Blackwell: Malden, Oxford & Chichester. pp. 307-319.

Robbins, P. & Heikkinen, H. (2006) New applications of political ecology for the Nordic context. *Nordia Geographical Publications*, 35, 3-8.

Robbins, P. & Bishop, K.M. (2008) There and back again: epiphany, disillusionment, and rediscovery in political ecology. *Geoforum*, 39, 747-755.

Robbins, P. & Marks, B. (2010) Assemblage geographies. In: *The SAGE handbook of social geographies*. Eds. Smith, S.J., Pain, R., Marston, S.A. & Jones III, J.P. SAGE: Los Angeles, London, New Delhi, Singapore & Washington DC. pp. 176-194.

Robbins, P. & Moore, S. (2012) Ecological anxiety disorder: diagnosing the politics of the Anthropocene. *Cultural Geographies*, 20, 3-19.

Robbins, P., Farnsworth, R. & Jones III, J.P. (2008) Insects and institutions: managing emergent hazards in the U.S. southwest. *Journal of Environmental Policy & Planning*, 10, 95-112.

Robinson, P.A. (2006) Cattle subsidies in Northern Ireland 1990-2005: their influence on cattle demography, and consequent significance for bovine tuberculosis and brucellosis incidence. Dissertation in part fulfilment of the requirements of the RCVS Diploma in State Veterinary Medicine. Royal College of Veterinary Surgeons: London.

Robinson, P.A., Epperson, W.B., Huston, C.L., Pace, L.W., Wills, R.W. & Cosby, A. G. (2012a) Factors influencing diagnostic sample submission by food animal veterinarians in Mississippi. *Veterinaria Italiana*, 48, 31-39.

Robinson, P. A., Corner, L. A. L., Courcier, E. A., McNair, J., Artois, M., Menzies, F. D. & Abernethy, D. A. (2012b) BCG vaccination against tuberculosis in European badgers (*Meles meles*): a review. *Comparative Immunology, Microbiology and Infectious Diseases,* 35, 277–287.

Robinson, P.A. & Epperson, W.B. (2013) Farm animal practitioners' views on their use and expectations of veterinary diagnostic laboratories. *Veterinary Record*, 172, 503.

Robinson, P. A., Courcier, E.A., Gordon, A.W., Menzies, F.D. & Abernethy, D.A. (2014) Survival and risk factors for lateral spread of bovine TB in cattle herds exposed to infection at pasture in Northern Ireland. Society for Veterinary Epidemiology and Preventive Medicine. Proceedings of a meeting held in Dublin, Ireland, 26-28 March 2014. pp. 211-221.

Roche, M. (2010) Historical research and archival sources. In: *Qualitative research methods in human geography*. Third edition. Ed. Hay, I. Oxford University Press: Don Mills, ON. pp. 173-190.

Rocheleau, D.E. (2008) Political ecology in the key of policy: from chains of explanation to webs of relation. *Geoforum*, 349, 716-727.

Rocheleau, D. (2011) Rooted networks, webs of relation, and the power of situated science: bringing the models back down to earth in Zambrana. In: *Knowing Nature: conversations at the intersection of political ecology and science studies*. Eds. Goldman, M.J., Nadasdy, P. & Turner, M.D. University of Chicago Press: Chicago & London. pp. 209-226.

Roe, E.M. (1989) Narrative analysis for the policy analyst: a case study of the 1980-1982 medfly controversy in California. *Journal of Policy Analysis and Management*, 8, 251-273.

Roe, E. & Greenhough, B. (2014) Experimental partnering: interpreting improvisatory habits in the research field. *International Journal of Social Research Methodology*, 17, 45-57.

Roper, T. J. (2010) *Badger*. Collins: London.

Rose, G. (1997) Situating knowledges: positionality, reflexivities and other tactics. *Progress in Human Geography*, 21, 305-320.

Rose, M. & Wylie, J. (2006) Guest editorial: animating landscape. *Environment and Planning D: Society and Space*, 24, 475-479.

Rudy, A.P. & Gareau, B.J. (2005) Actor-Network Theory, Marxist economics, and Marxist political ecology. *Capitalism Nature Socialism,* 16, 85-90.

Russell, G.P. (1985) Tuberculosis in cattle in Northern Ireland: 1949-1984. Department of Agriculture for Northern Ireland, unpublished paper, April 1985.

Ryszkowski, L. (1992) Energy and material flows across boundaries in agricultural landscapes. In: *Landscape boundaries: consequences for biotic diversity and ecological flows*. Eds. Hansen, A.J. & di Castri, F. Springer-Verlag: New York, Berlin, Heidelberg, London, Paris, Tokyo, Hong Kong, Barcelona & Budapest. pp. 270-284.

Saunders, A. & Moles, K. (2013) The spatial practice of public engagement: 'doing' geography in the South Wales valleys. *Social and Cultural Geography,* 14, 23-40.

Sayer, A. (1992) *Method in social science: a realist approach*. Second edition. Routledge: London & New York.

Sayer, A. (2011) *Why things matter to people: social science, values and ethical life*. Cambridge University Press: Cambridge.

Sayer, A. (2013) Looking forward to new realist debates. *Dialogues in Human Geography*, 3, 22-25.

Sayre, N. F. (2004) Viewpoint: the need for qualitative research to understand ranch management. *Journal of Range Management*, 57, 668-674.

Sayre, N.F. (2008) The genesis, history, and limits of carrying capacity. *Annals of the Association of American Geographers*, 98, 120-134.

Sayre, N.F., de Buys, W., Bestelmeyer, B.T. & Havstad, K.M. (2012) "The range problem" after a century of rangeland science: new research themes for altered landscapes. *Rangeland Ecology & Management*, 65, 545-552.

Scanlon, M.P. & Quinn, P.J. (2000) Inactivation of *Mycobacterium bovis* in cattle slurry by five volatile chemicals. *Journal of Applied Microbiology*, 89, 854-861.

Schaffer, S. (1995) Accurate measurement is an English science. In: *The values of precision*. Ed. Wise, M.N. Princeton University Press: Princeton, NJ. pp. 135-172.

Schmitt, S.M., O'Brien, D.J., Bruning-Fann, C.S. & Fitzgerald, S.D. (2002) Bovine tuberculosis in Michigan wildlife and livestock. *Annals of the New York Academy of Sciences*, 969, 262-268.

Schroeder, R.A. (2005) Debating the place of political ecology in the First World. *Environment and Planning A,* 37, 1045-1048.

Schroeder, E.C. & Cotton, W.E. (1907) The danger from tubercle bacilli in the environment of tuberculous cattle. Bulletin No. 99. United States Department of Agriculture Bureau of Animal Industry: Washington D.C.

Schubert, C. (2011) Making sure. A comparative micro-analysis of diagnostic instruments in medical practice. *Social Science & Medicine*, 73, 851-857.

Scoones, I. & Wolmer, W. (2007) Land, landscapes and disease: the case of Foot and Mouth in Southern Zimbabwe. *South African Historical Journal*, 58, 42-64.

Scott, J.C. (1985) *Weapons of the weak: everyday forms of peasant resistance*. Yale University Press: New Haven and London.

Scott, J. C. (1998) *Seeing like a state: how certain schemes to improve the human condition have failed*. Yale University Press: New Haven & London.

Scott, J.C. (2009) *The art of not being governed: an anarchist history of upland Southeast Asia*. Yale University Press: New Haven & London.

Scott, C.A., Robbins, P.F. & Comrie, A.C. (2012) The mutual conditioning of humans and pathogens: implications for integrative geographical scholarship. *Annals of the American Geographers*, 102, 977-985.

Sellick, J. & Yarwood, R. (2013) Placing livestock in landscape studies: pastures new or out to graze? *Landscape Research*, 38, 404-420.

Shaw, I.G.R. (2012) Towards an evental geography. *Progress in Human Geography*, 36, 613-627.

Shaw, IGR & Meehan, K. (2013) Force-full: power, politics and object-oriented philosophy. *Area*, 45, 216-222.

Shaw, I.G.R., Robbins, P.F. & Jones III, J.P. (2010) A bug's life and the spatial ontologies of mosquito management. *Annals of the American Geographers*, 100, 373-392.

Shmueli, D.F. (2008) Framing in geographical analysis of environmental conflicts: theory, methodology and three case studies. *Geoforum*, 39, 2048-2061.

Sin, C.H. (2003) Interviewing in 'place': the socio-spatial construction of interview data. *Area*, 35, 305-312.

Singleton, V. (2010) Good farming: Control or care? In: *Care in practice*. Eds. Mol, A., Moser, I. & Pols, J. Transaction Publishers: Bielefeld. pp. 235-256.

Singleton, V. (2012) When contexts meet: feminism and accountability in UK cattle farming. *Science, Technology, & Human Values*, 37, 404-433.

Sismondo, S. (2004) *An introduction to science and technology studies*. Blackwell Publishing Ltd: Malden, Oxford, Carlton.

Sismondo, S. (2010) Science and Technology Studies and an engaged program. In: *The handbook of Science and Technology Studies*. Third edition. Eds. Hackett, E.J., Amsterdamska, O., Lynch, M. & Wajcman, J. The MIT Press: Cambridge, MA & London. pp. 13-31.

Skop, E. (2006) The methodological potential of focus groups in population geography. *Population, Space and Place*, 12, 113-124.

Skuce, R.A., Mallon, T.R., McCormick, C.M., McBride, S.H., Clarke, G., Thompson, A., Couzens, C., Gordon, A.W. & McDowell, S.W. (2010) *Mycobacterium bovis* genotypes in Northern Ireland: herd-level surveillance (2003 to 2008). *Veterinary Record*, 167, 684-689.

Sleeman, D.P., Davenport, J. & Fitzgerald, A. (2008) Incidence of visits by badgers to farmyards in Ireland in winter. *The Veterinary Record*, 163,724.

Sligo, F.X. & Massey, C. (2007) Risk, trust and knowledge networks in farmers' learning. *Journal of Rural Studies*, 23, 170-182.

Sloterdijk, P. (2004) *Sphären III: Schäume*. Suhrkamp Verlag : Frankfurt am Main.

Sloterdijk, P. (2009) *Terror from the air*. Trans. by Patton, A. & Corcoran, S. Semiotext(e): Los Angeles.

Smith, A.F., Mort, M., Goodwin, D. & Pope, C. (2003) Making monitoring 'work': human-machine interaction and patient safety in anaesthesia. *Anaesthesia*, 58, 1070-1078.

Smith, E., Marsden, T., Flynn, A. & Percival, A. (2004) Regulating food risks: rebuilding confidence in Europe's food? *Environment and Planning C: Government and Policy*, 22, 543-567.

Sørensen, E. & Torfing, J. (2007) Introduction. Governance network research: towards a second generation. In: *Theories of democratic network governance*. Eds. Sørensen, E. & Torfig, J. Palgrave Macmillan: Basingstoke & New York. pp. 1-21.

Spencer, A. (2011) One body of evidence, three different policies: bovine tuberculosis policy in Britain. *Politics*, 31, 91-99.

Srinivasan, K. (2013) The biopolitics of animal being and welfare: dog control and care in the UK and India. *Transactions of the Institute of British Geographers*, 38, 106-119.

Starr, P. (1987) The sociology of official statistics. In: *The politics of numbers*. Eds. Alonso, W. & Starr, P. Russell Sage Foundation: New York. pp. 7-57.

St. Martin, K. & Pavlovskaya, M. (2009) Ethnography. In: *A companion to environmental geography*. Eds. Castree, N., Demeritt, D., Liverman, D. & Rhoads, B. Blackwell Publishing Ltd.: Malden, Oxford & Chichester. pp. 370-384.

Stoller, P. (2012) Immunology and the between. *Cultural Anthropology,* 27, 175-180.

Stringer, C. & Le Heron, R. (2008) *Agri-food commodity chains and globalising networks: the dynamics of economic space*. Ashgate: Aldershot & Burlington, VT. pp. 244.

Sullivan, E.W. (1979a) Tuberculosis of cattle (1). *Agriculture in Northern Ireland*, 53, 2, 337-340.

Sullivan, E.W. (1979b) Tuberculosis of cattle (2). *Agriculture in Northern Ireland*, 54, 1, 13-17.

Sutherland, L-A., Burton, R.J.F., Ingram, J., Blackstock, K., Slee, B. & Gotts, N. (2012) Triggering change: towards a conceptualization of major change processes in farm decision-making. *Journal of Environmental Management*, 104, 142-151.

Sutherland, L-A., Mills, J., Ingram, J., Burton, R.J.F., Dwyer, J. & Blackstock, K. (2013) Considering the source: commercialisation and trust in agri-environmental information and advisory services in England. *Journal of Environmental Management*, 118, 96-105.

Swaisgood, R.R. & Sheppard, J. (2011) Hope springs eternal: biodiversity conservation requires that we see the glass as half full. *BioScience*, 61, 427-428.

Swyngedouw, E. (2004) Globalisation or 'glocalisation'? Networks, territories and rescaling. *Cambridge Review of International Affairs*, 17, 25-48.

Swyngedouw, E. & Heynen, N.C. (2003) Urban political ecology, justice and the politics of scale. *Antipode*, 35, 898-918.

Szerszynski, B., Heim, W. & Waterton, C. (2003) Introduction. In: *Nature performed: environment, culture and performance*. Blackwell Publishing: Oxford & Malden, MA. pp. 1-14.

Tadros, M. (2010) Scapepigging: H1N1 influenza in Egypt. In: *Epidemics: science, governance and social justice*. Eds. Dry, S. & Leach, M. Earthscan: London & Washington, DC. pp. 213-238.

Taylor, P.J. (2011) Agency, structuredness, and the production of knowledge within intersecting processes. In: *Knowing nature: conversations at the intersection of political ecology and science studies*. Eds. Goldman, M.J., Nadasdy, P. & Turner, M.D. University of Chicago Press: Chicago. pp. 81-98.

Tedesco, C., Ruiz, M. & McLafferty, S. (2010) Mosquito politics: local vector control policies and the spread of West Nile Virus in the Chicago region. *Health & Place*, 16, 1188-1195.

Thompson, M. & Warburton, M. (1985) Uncertainty on a Himalayan scale. *Mountain Research and Development*, 5, 115-135.

Thrupp, L.A. (1993) Political ecology of sustainable rural development: dynamics of social and natural resource degradation. In: *Food for the future: conditions and contradictions of sustainability*. Ed. Allen, P. John Wiley & Sons Inc: New York. pp. 47-73.

Tolhurst, B.A., Delahay, R.J., Walker, N.J., Ward, A.I. & Roper, T.J. (2009) Behaviour of badgers (*Meles meles*) in farm buildings: opportunities for the transmission of *Mycobacterium bovis* to cattle? *Applied Animal Behaviour Science*, 117, 103-113.

Tolia-Kelly, D.P. (2007) Participatory art: capturing spatial vocabularies in a collaborative visual methodology with Melanie Carvalho and South Asian women in London, UK. In: *Participatory action research approaches and methods: connecting people, participation and place*. Eds. Kindon, S., Pain, R. & Kesby, M. Routledge: London & New York. pp. 132-140.

Tooke, J. (2000) Betweenness at work. *Area*, 32, 217-223.

Torgerson, P.R. & Torgerson, D.J. (2010) Public health and bovine tuberculosis: what's all the fuss about? *Trends in Microbiology*, 18, 67-72.

Tsouvalis, J., Seymour, S. & Watkins, C. (2000) Exploring knowledge-cultures: precision farming, yield mapping, and the expert-farmer interface. *Environment and Planning A,* 32, 909-924.

Turner, M. (1993) Overstocking the range: a critical analysis of the environmental science of Sahelian pastoralism. *Economic Geography*, 69, 402-421.

Turner, M.D. (2011) Production of environmental knowledge: scientists, complex natures, and the question of agency - Introduction. In: *Knowing nature: conversations at the intersection of political ecology and science studies*. Eds. Goldman, M.J., Nadasdy, P. & Turner, M.D. University of Chicago Press: Chicago & London. pp. 25-29.

Tweddle, N.E. & Livingstone, P. (1994) Bovine tuberculosis control and eradication programs in Australia and New Zealand. *Veterinary Microbiology*, 40, 23-39.

Valentine, G. (1999) Doing household research: interviewing couples together and apart. *Area*, 31, 67-74.

Valentine, G. (2005) Tell me about ... using interviews as a research methodology. In: *Methods in human geography: a guide for students doing a research project*. Eds. Flowerdew, R. & Martin, D. Person Education Limited: Harlow. pp. 110-127.

Vanclay, F. & Enticott, G. (2011) The role and functioning of cultural scripts in farming and agriculture. *Sociologia Ruralis*, 51, 256-271.

Van der Ploeg, J.D. (2008) *The new peasantries: struggles for autonomy and sustainability in an era of empire and globalization*. Earthscan: London & Sterling, VA.

Van der Ploeg, J.D. (2010) The peasantries of the twenty-first century: the commoditisation debate revisited. *The Journal of Peasant Studies*, 37, 1-30.

Van Dijk, J. (2013) Towards risk-based test protocols: estimating the contribution of intensive testing to the UK bovine tuberculosis problem. *PLOS ONE*, 8(5), e63961. doi:10.1371/journal.pone.0063961.

Van Loon, J. (2005) Epidemic space. *Critical Public Health*, 15, 39-52.

Vayda, A.P. & Walters, B.B. (1999) Against political ecology. *Human Ecology*, 27, 167-179.

Volkova, V.V., Howey, R., Savill, N.J. & Woolhouse, M.E.J. (2010) Potential for transmission of infections in networks of cattle farms. *Epidemics*, 2, 116-122.

Waddington, K. (2004) To stamp out “so terrible a malady”: bovine tuberculosis and tuberculin testing in Britain, 1890-1939. *Medical History*, 48, 29-48.

Walby, S. (1999) The new regulatory state: the social powers of the European Union. *British Journal of Sociology*, 50, 118-140.

Wald, P. (2008) *Contagious: cultures, carriers, and the outbreak narrative*. Duke University Press: Durham, NC & London.

Walford, N. (2003) Productivism is allegedly dead, long live productivism. Evidence of continued productivist attitudes and decision-making in south-east England. *Journal of Rural Studies*, 19, 491-502.

Walker, P.A. (2005) Political ecology: where is the ecology? *Progress in Human Geography*, 29, 73-82.

Walker, P.A. (2006) Political ecology: where is the policy? *Progress in Human Geography*, 30, 382-395.

Ward, N. (1993) The agricultural treadmill and the rural environment in the post-productivist era. *Sociologia Ruralis*, 33, 348-364.

Ward, A.I., Etherington, T.R. & Smith, G.C. (2008) Exposure of cattle to *Mycobacterium bovis* excreted by deer in southwest England: a quantitative risk assessment. Consultancy report to TB Programme, Food and Farming Group, DEFRA, London, 12 July 2008. Central Science Laboratory: York.

Watchorn, R.C. (1965) *Bovine tuberculosis eradication scheme 1954-1965.* Department of Agriculture and Fisheries: Dublin.

Watkins, M.D. & Bazerman, M.H. (2003) Predictable surprises: the disasters you should have seen coming. *Harvard Business Review*, 81, 72-85.

Watts, M. & Goodman, D. (1997) Agrarian questions: global appetite, local metabolism: nature, culture, and industry in *fin-de-siècle* agro-food systems. In: *Globalising food: agrarian questions and global restructuring*. Routledge: London & New York. pp. 1-32.

Watts, M.J. & McCarthy, J. (1997) Nature as artifice, nature as artefact: development, environment and modernity in the late twentieth century. In: *Geographies of economies*. Eds. Lee, R. & Wills, J. Arnold: London & New York. pp. 71-86.

Watts, M. & Peet, R. (2004) Liberating political ecology. In: *Liberation ecologies, second edition: environment, development, social movements*. Eds. Peet, R. & Watts, M. Routledge: London & New York. pp. 3-47.

Welsh Government (2014) Bovine TB eradication programme IAA badger vaccination project - Year 2 Report. Available online at: http://wales.gov.uk/docs/drah/publications/130708iaareport.pdf. Accessed 10 May 2014.

Whatmore, S. (1993) Agricultural geography. *Progress in Human Geography*, 17, 84-91.

Whatmore, S. (2002) *Hybrid geographies: natures cultures spaces*. Sage: London.

Whatmore, S. (2003) Generating materials. In: *Using social theory: thinking through research*. Eds. Pryke, M., Rose, G. & Whatmore, S. SAGE Publications Ltd.: London, Thousand Oaks & New Delhi. pp. 89-104.

Whelan, C., Shuralev, E., Kwok, H.F., Kenny, K., Duignan, A., Good, M., Davis, W.C. & Clarke, J. (2011) Use of a multiplex enzyme-linked immunosorbent assay to detect a subpopulation of *Mycobacterium bovis*-infected animals deemed negative or inconclusive by the single intradermal comparative tuberculin skin test. *Journal of Veterinary Diagnostic Investigation*, 23, 499-503.

White, P.C.L., Böhm, M., Marion, G. & Hutchings, M.R. (2008) Control of bovine tuberculosis in British livestock: there is no 'silver bullet'. *Trends in Microbiology*, 16, 420-427.

Wiens, J.A. (1992) Ecological flows across landscape boundaries: a conceptual overview. In: *Landscape boundaries: consequences for biotic diversity and ecological flows*. Eds. Hansen, A.J. & di Castri, F. Springer-Verlag: New York, Berlin, Heidelberg, London, Paris, Tokyo, Hong Kong, Barcelona & Budapest. pp.217-235.

Wilkinson, K., Grant, W.P., Green. L.E., Hunter, S., Jeger, M.J., Lowe. P., Medley, G.F., Mills, P., Phillipson, J., Poppy, G.M. & Waage, J. (2011) Infectious diseases of animals and plants: an interdisciplinary approach. *Philosophical Transactions of the Royal Society B*, 366, 1933-1942.

Williamson, M. (1996) *Biological invasions*. Chapman & Hall: London, Weinheim, New York, Tokyo, Melbourne & Madras.

Winner, L. (1986) *The whale and the reactor: a search for limits in an age of high technology*. The University of Chicago Press: Chicago & London.

Wise, M.N. (1995) Introduction. In: *The values of precision*. Ed. Wise, M.N. Princeton University Press: Princeton, NJ. pp. 3-13.

Withers, C.W.J. (2002) Constructing 'the geographical archive'. *Area*, 34, 303-311.

Wolford, W. (2004) The land is ours now: spatial imaginaries and the struggle for land in Brazil. *Annals of the Association of American Geographers*, 94, 409-424.

Wolleswinkel, A. & Weersink, A. (2001) Farmer emigration: the case of Dutch dairy farmers moving to Ontario. *Livestock Production Science*, 69, 197-205.

Woods, J.C.H. (1963) Agriculture in Northern Ireland, with a particular reference to dairying. *Journal of the Society of Dairy Technology*, 16, 178-214.

Woods, M. (2009) Rural geography: blurring boundaries and making connections. *Progress in Human Geography*, 33, 849-858.

Woods, M. (2010) Performing rurality and practising rural geography. *Progress in Human Geography*, 34, 835-846.

Woods, M. (2011) Diving in again – a response to commentaries on 'Applied policy research and critical human geography: some reflections on swimming in murky waters'. *Dialogues in Human Geography*, 1, 242-245.

Woods, M. (2013) Regions engaging globalization: a typology of regional responses in rural Europe. *Journal of Rural and Community Development*, 8, 113-126.

Woods, M. & Gardner, G. (2011) Applied policy research and critical human geography: some reflections on swimming in murky waters. *Dialogues in Human Geography*, 1, 198-214.

Wynne, B. (1991) Knowledges in context. *Science, Technology & Human Values*, 16, 111-121.

Wynne, B. (1996) May the sheep safely graze? A reflexive view of the expert-lay knowledge divide. In: *Risk, environment and modernity: towards a new ecology*. Eds. Lash, S., Szerszynski, B. & Wynne, B. Sage: London, Thousand Oaks, New Delhi. pp. 44-83.

Wynne. B. (2007) Public participation in science and technology: performing and obscuring a political-conceptual category mistake. *East Asian Science, Technology and Society: an International Journal*, 1, 99-110.

Yarwood, R. & Evans, N. (2000) Taking stock of farm animals and rurality. In: *Animal spaces, beastly places*: *new geographies of human-animal relations*. Eds. Philo, C. & Wilbert, C. Routledge: London & New York. pp. 98-114.

Yarwood, R. & Evans, N. (2006) A Lleyn sweep for local sheep? Breed societies and the geographies of Welsh livestock. *Environment and Planning A,* 38, 1307-1326.

Yeung, H.W. (1997) Critical realism and realist research in human geography: a method or a philosophy in search for a method? *Progress in Human Geography*, 21, 51-74.

Zanella, G., Durand, B., Hars, J., Moutou, F., Garin-Bastuji, B., Duvauchelle, A., Fermé, M., Karoui, C. & Boschiroli, M.L. (2008) *Mycobacterium bovis* in wildlife in France. *Journal of Wildlife Diseases*, 44, 99-108.

Zanini, M.S., Moreira, E.C., Lopes, M.T., Mota, P. & Salas, C.E. (1998) Detection of *Mycobacterium bovis* in milk by Polymerase Chain Reaction. *Journal of Veterinary Medicine, Series B*, 45, 473–479.

Zimmerer, K.S. & Bassett, T.J. (2003) *Political ecology: an integrative approach to geography and environment-development studies*. The Guilford Press: New York & London.